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DOI (link to publication from Publisher):
10.5278/vbn.phd.eng.00018

Publication date:
2017

Document Version
Publisher's PDF, also known as Version of record

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BY
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DISSERTATION SUBMITTED 2017

AALBORG UNIVERSITY
DENMARK

Aligning Supply and Demand in Grocery Retailing

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This doctoral thesis is subject to a cotutelle/double degree between Norwegian University of Science and Technology, Norway and Aalborg University, Denmark

Norwegian University of Science and Technology
Faculty of Engineering
Dept. of Mechanical and Industrial Engineering
Production Management Group

Aalborg University
Faculty of Engineering and Science
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Dissertation submitted: December 2017

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PhD Series - Aalborg University: Faculty of Engineering and Science,
Aalborg University

Department - Aalborg University: Department of Materials and Production

ISSN (online) - Aalborg University: 2446-1636
ISBN (online) - Aalborg University: 978-87-7210-110-1

ISBN: 978-82-326-2802-5 (Printed)
ISBN: 978-82-326-2803-2 (Electronic)
ISSN: 1503-8181

Published by:
Aalborg University Press
Skjernvej 4A, 2nd floor
DK – 9220 Aalborg Ø
Phone: +45 99407140
aauf@forlag.aau.dk
forlag.aau.dk

Printed in Norway, 2017

Acknowledgements

I hope it goes without saying that this thesis is the result of inspiration, discussions, and encouragement from countless people. I would like to take this opportunity to express my gratitude to those who have supported and strengthened this work.

Firstly, I had the great pleasure of having not only one but two main supervisors: Heidi C. Dreyer and Hans-Henrik Hvolby. Heidi, thank you for guiding me through the academic arena, reviewing ideas and papers, as well as including me in your network of both international researchers and practitioners. Hans-Henrik, I cannot thank you enough for the countless hours you have spent on improving and refining my work as well as your patience and kindness towards me. Thank you. For my co-supervisor, thank you Jan Ola Strandhagen for continuously raising the quality and unambiguity of my work through your thoughtful questions and ideas. To all three of you, I am thankful for the willingness and support you have provided through the whole journey, as well as the possibility and freedom I had for pursuing research topics and methods of my personal interest.

Furthermore, I am very grateful for the support and encouragement I have received from Iskra Dukovska-Popovska and Kenn Steger-Jensen during my many visits at Aalborg University. You managed to both challenge and help me with individual papers as well as structuring my research into one entity. Similarly, I would like to thank Jacques Trienekens for welcoming me at Wageningen University and ensuring a fruitful research stay. Also, I appreciate the great amount of support from Peter Falster (DTU) and Chris Martin (UniSA) for your keen-eyes on details by reading, commenting, and editing papers and this thesis.

I feel indebted to express my gratitude to the Norwegian grocery retailer and their network of suppliers and stores which have been part of this research. Through you, I have gained practical insights and understandings. It has been the driving force for many of my research papers, and it has provided me with a foundation for further expertise in the grocery retailing sector.

A special ‘thank you’ goes to Peter Larsen. You convinced me that I was capable of conducting a PhD, and you have kept me motivated by sharing your experiences and reflections of the PhD process. I am very thankful this and for the friendship that has evolved.

I have received immense support from my family. I would like to thank my parents, Marian Kiil and Kurt Kiil, for their continuous curiosity for my work and well-being. Also, I would like to thank my brother and his wife, Klaus Kiil and Monica Kiil, and my two nephews, Valde Kiil and Villi Kiil. You have unquestionably eased many evenings and nights and filled me with smile and laughter.

Finally, Lene Vestergaard, you have called me crazy many times for spending so many hours on this. However, you have always, wholeheartedly, supported me with your endless joy and compassion. I cannot express how grateful I am for you and your undivided support. I love you.

Trondheim, October 2017
Kasper Kiil

Summary

The aim of aligning supply and demand in grocery retailing is to achieve availability of products while keeping waste, transportation, handling cost, and inventory levels at a minimum. Availability is defined as having a product in its desired form, flavor, size, and saleable condition in the expected location (from the consumers perspective) in stock when the consumer reaches for the product (Aastrup and Kotzab, 2010; ECR, 2003). Ensuring high availability is necessary to stay competitive in grocery retailing (ECR, 2003). If the products are not available consumers may switch brand or store, leave without purchasing anything, or purchase a different style or size. This affects grocery retailers' reputation, revenue, and ultimately profit. Grocery retailers should not achieve this availability simply by overflowing stores with products because unsold products will end up being wasted when they expire. Today, we are wasting enough food along the supply chain to feed another billion people (Kummu et al., 2012). The size of the problem is remarkable, and even small improvements can have a significant impact, and grocery retailers should aim to align their supply and demand (Beddington, 2011).

This PhD thesis examines how grocery retailers can align supply and demand through improved decision making in their planning processes. Two underlying hypotheses are the ability of "*additional information to resolve uncertainty and improve the match between supply and demand*" (Ketzenberg et al., 2007, p. 1236) and that "*improved supply chain wide transparency of demand information (…) can reduce supply chain wide food waste*" (Mena et al., 2014, p. 152). By combining these two, it is expected that additional information has the ability improve the alignment of supply and demand, which will be manifested by improved availability and reduced food waste.

The theoretical foundation of this thesis is positioned within Operations Management and centers upon information sharing, automatic replenishment, and sales and operations planning. On a general level information sharing is often discussed as one of the major means to enhance supply chain coordination (Arshinder et al., 2008) and thereby supply chain performance (Baihaqi and Sohal, 2013; Barratt and Oke, 2007; Myrelid, 2015; Sezen, 2008). The information utilization concept (Jonsson and Myrelid, 2016; Myrelid, 2015) emphasizes that shared information should be incorporated at the receiver's processes before it can create additional value for the receiving company and the whole supply chain. However, the information utilization concept is in its infancy and how to characterize shared information and link it to planning processes remains an open question.

One common way of utilizing shared information in grocery retailing and create efficiency gains is through an automatic replenishment system. It originates from the *efficient consumer response* concept introduced in the early 1990's in grocery retailing (Salmon, 1993). An automatic replenishment system generates orders (proposals) based on shared point-of-sales and waste information, and it became an increasingly popular method to improve product availability. However, the usefulness of information sharing and automatic replenishment systems for reducing food waste as well as its applicability for replenishing products with a short shelf life is not adequately covered by the current academic literature. Consequently, as the main topic for this thesis it is examined:

1. How does information sharing contribute to align supply and demand in grocery retailing?
    a. How is information sharing characterized in grocery retailing?
    b. What is the impact of information sharing in grocery retailing?

Efficient consumer response also included strategies, such as *efficient promotions* and *efficient product introductions* for managing stimulated demand. Today managing stimulated demand remains one of the main challenges in grocery retailing (Martec, 2017; Moussaoui et al., 2016). Grocery retailers rely on these type of activities to drive sales and increase consumer visits to the stores. Nevertheless, its massive impact on logistics necessitates proper coordination to align supply and demand and it is often necessary to start planning several months in advance to prepare the whole supply chain.

In sales and operations planning, the underlying idea is to plan across the organization (and whole supply chain) for activities which take months of preparation, e.g., extra recruitment, building up seasonal inventory, or allocate products between facilities (Jacobs et al., 2011; Thomé et al., 2012). Thus, applying sales and operations planning for managing stimulated demand in grocery retailing appears tempting, but has not received any attention in the academic literature. Therefore, as a subordinate topic this thesis examines:

2. How do grocery retailers effectively align supply and stimulated demand?

For research question 1 two literature studies were conducted to identify the characteristics of shared information and used to develop the information utilization concept. Afterwards, a questionnaire was distributed to suppliers, customers, transportation provider, and the grocery retailer in a Norwegian food supply chain to understand their use of information sharing. The output from the questionnaire was used to demonstrate the usefulness and applicability of the identified information sharing characteristics and the information utilization concept in grocery retailing.

Additionally, the thesis contains three studies which examine the potential improvement of information sharing and has played a central role in the whole PhD period. A multiple case study with access to 54 products across 21 stores was undertaken to examine the impact on food waste and freshness of products in the stores by comparing the automatic replenishment to manual replenishment. Furthermore, a discrete event simulation model was built to evaluate the impact of information sharing for automatic replenishment and inventory allocations for products with a short shelf life. The model simulates the inventory system of one product in a divergent supply chain with one warehouse supplying 232 stores in different sizes, profiles, and delivery frequencies. The model includes both known replenishment and inventory allocation policies from literature, as well as newly proposed policies that were developed as part of this PhD project.

For research question 2 it was examined how grocery retailers planned stimulated demand activities, as well as if and how sales and operations planning could be applied for this purpose. A single case study with one of Norway's largest grocery retailers was used to form an initial understanding of these activities. This was later extended to a multiple case study including a second grocery retailer from Norway, one from Britain, and a grocery wholesaler from Finland.

The main contributions of this thesis, regarding information sharing, can be summarized as:

- Identification and synthesis of information facets to characterize shared information which combined with a proposed mapping tool to information sharing adds to the advancement of the information utilization concept in grocery retailing
- An empirical evaluation of automatic replenishment which indicated an average of 17.8% reduction in food waste across 54 products and 5.2% improvement in the weighted average remaining shelf life (freshness) of the products in the stores. The findings also suggest the improvement is dependent on the shelf life of the product.
- A modified age-based replenishment and two inventory allocation policies for perishables. Based on simulation runs for one year the findings indicated that:
    - Increased information sharing for replenishment of perishables with a shelf life between 4 to 11 days can on average improve availability with 10.3% and reduce waste with 10.7% while slightly decreasing the inventory level with 0.3%.
    - Utilizing shared information with the proposed guidelines for inventory allocation of perishable products with a shelf life between 4 and 11 days, showed a 3.3% improvement in availability and 3.8% reduction in waste. However, these results are possible to achieve with the information already embedded in a traditional automatic replenishment system, which means no additional investment in data collection is needed.
    - Information sharing should be differentiated based on (at least) the shelf life of the product and the delivery frequency to the stores to reap the highest benefits of information sharing.

The secondary contributions, regarding demand stimulating activities, can be summarized as:

- A proposed adapted sales and operations planning process for managing stimulating demand activities, which considers the characteristics of grocery retailing
- Six propositions for how grocery retailers could improve cross-functional planning by use of IT, dedicated organizational resources, and by using a more formal evaluation of previous activities as input for the following planning cycles

For practitioners in grocery retailing, the findings and contributions of this thesis have a number of implications which can be summarized to the following advises:

- The use of information sharing is a continuous and iterative process. This thesis has provided a list of facets and a mapping tool to structure the information flow in the supply chain. Applying this scheme provides a visualization of what information that is utilized, what that potentially could be utilized, as well as suggestions for how to link information to planning processes.
- Differentiating information sharing and the subsequent planning processes based on product characteristics is beneficial. For replenishment and inventory allocation decisions, this thesis suggests that sharing and utilizing point-of-sales and waste data can improve the alignment of supply and demand. More detailed information about remaining shelf life becomes increasingly important and beneficial for products with a shelf life between 6 and 11 days and may enable automatic replenishment of these products.

- The additional sales volumes created by demand stimulating activities is an important part of the overall revenue, but it also greatly influences the underlying logistics required to handle these volumes. This should be reflected in a corresponding importance in the planning decisions across functions. This thesis provides a number of propositions for how to create such an importance and how to structure a tactical planning process to support this in grocery retailing.

Overall, this PhD thesis has contributed to how grocery retailers can align supply and demand. Especially by means of automatic replenishment and inventory allocations, but also by demonstrating how sales and operations planning could be useful in grocery retailing. The thesis aspires to support future discussions and development of grocery retailing by highlighting some of the possibilities for aligning supply and demand.

Sammendrag

Formålet med å balansere forholdet mellom forsyning og etterspørsel i dagligvarehandelen er å oppnå tilgjengelighet av produkter, samtidig som man holder matsvinn, transport- og håndteringskostnader og lagernivåer på et minimum. Tilgjengelighet forstås her som å ha et produkt tilgjengelig for forbruker på riktig sted, tid, i ønskede form, smak, størrelse og kvalitet (Aastrup og Kotzab, 2010; ECR, 2003). Å sikre høy tilgjengelighet er nødvendig for å kunne opprettholde konkurransestyrke i dagligvarehandelen (ECR, 2003). Hvis produktene ikke er tilgjengelig, vil en kunne risikere at forbrukerne velger å kjøpe et substituttprodukt, forlater butikken uten å ha kjøpt noe eller å bytte butikk. Dette påvirker butikkens omdømme, omsetning og dermed fortjeneste. Høy tilgjengelighet i dagligvarebutikker bør ikke oppnås gjennom for høye varebeholdninger, da usolgte produkter vil ende opp som matsvinn om de ikke selges før utløpsdatoen. Summen av all mat som i dag kastes i dagligvarehandelen vil kunne ha mettet ytterligere én milliard mennesker (Kummu et al., 2012). Størrelsen på dette problemet er signifikant, og kun små justeringer og forbedringer kan føre til store positive effekter. Derfor er det viktig at dagligvarehandelen greier å balansere forholdet mellom forsyning og etterspørsel (Beddington, 2011).

Denne doktorgradsavhandlingen undersøker hvordan dagligvarehandelen bedre kan balansere forholdet mellom forsyning og etterspørsel gjennom mer presise beslutninger i planleggingsprosessene. To underliggende antakelser er at "*informasjonsdeling kan redusere usikkerhet og forbedre forholdet mellom forsyning og etterspørsel*" [fritt oversatt] (Ketzenberg et al., 2007, s. 1236) og at "*forbedret innsyn i etterspørselsinformasjon i forsyningskjeden (...) kan redusere matsvinnet i forsyningskjeden*" [fritt oversatt] (Mena et al., 2014, s. 152). Ved å kombinere disse to antakelsene er forventningen at informasjonsdeling bidrar til å forbedre tilpasningen mellom forsyning og etterspørsel, som igjen vil føre til forbedret tilgjengelighet og redusert matsvinn.

Avhandlingens teoretiske fundamentet er innen Operations Management og er sentrert rundt informasjonsdeling, automatisk vareforsyning av varer, og *sales and operations planning*. Informasjonsdeling er ofte fremhevet som et av de viktigste midlene for å koordinere forsyningskjeden (Arshinder et al., 2008) og dermed et middel for å forbedre forsyningskjedens prestasjoner (Baihaqi and Sohal, 2013; Barratt and Oke, 2007; Myrelid, 2015; Sezen, 2008). Forskning på informasjonsdeling (Jonsson og Myrelid, 2016; Myrelid, 2015) har påvist at informasjon må kunne utnyttes i mottakerens prosesser før den kan skape verdi for de involverte parter i forsyningskjeden. Kunnskapen om deling av informasjon i verdikjeden er under utvikling, og hvordan informasjonen som skal deles kan karakteriseres og kobles til planleggingsprosesser er et sentralt spørsmål.

I dagligvarehandelen brukes ofte informasjonsdeling i automatiske vareforsynings systemer, som stammer fra Efficient Consumer Response lansert i starten av 1990-årene (Salmon, 1993). Automatisk vareforsyning fungerer ved at ordrer (forslag) genereres basert på salgs- og svinninformasjon fra butikk. Det er en mye anvendt metode i handelen for å forbedre tilgjengeligheten og automatisere bestillingsprosessene. Samtidig er ikke nytten av informasjonsdeling i automatisk vareforsyning, som middel for å redusere matsvinn og mot anvendelse på produkter med kort holdbarhet, tilstrekkelig undersøkt i eksisterende akademisk litteratur. Denne avhandlingen har derfor følgende hovedfokus:

1. Hvordan bidrar informasjonsdeling til å tilpasse forholdet mellom forsyning og etterspørsel i dagligvarehandelen?
    a. Hva karakteriserer informasjonsdeling i dagligvarehandelen?
    b. Hvilken innvirkning har informasjonsdeling på dagligvarehandelen?

Ut over automatisk vareforsyning inkluderer Efficient Consumer Response strategier som styrer kampanjer og introduksjon av nye produkter, som primært brukes for å stimulere til økt salg i butikk. Salgsfremmende tiltak i form av kampanjer og nye produktlanseringer er en av de største utfordringene logistikkmessig i dagligvarehandelen (Martec, 2017; Moussaoui et al., 2016). Markedsaktiviteter som kampanjer skaper store variasjonene i omsetningen som igjen fører til press på logistikk systemet og usikkerhet i planleggingen. Derfor er det også vanlig å starte planleggingen av forsyningskjeden flere måneder i forveien av eksempelvis en kampanje for å sikre at produktene er tilgjengelig i kampanjeperioden.

I *sales and operations planning* er ideen at man planlegger på tvers av funksjonene i bedriften (og i noen tilfeller hele forsyningskjeden) for aktiviteter som krever lang forberedelse, f.eks. ekstra bemanning, lageroppbygging eller allokering av produkter mellom fabrikker og lagre (Jacobs et al., 2011; Thomé et al., 2012). Anvendelsen av *sales and operations planning* til å styre salgsfremmende aktiviteter i dagligvarehandelen virker derfor relevant, men har ikke tidligere blitt undersøkt i akademisk litteratur. Som et underordnet emne undersøker derfor denne avhandlingen:

2. Hvordan balanseres forholdet mellom forsyning og etterspørsel effektivt i dagligvarehandelen for stimulerende salgsaktiviteter?

For å besvare det første forskningsspørsmålet ble det utført to litteraturstudier for å identifisere karakteristikkene ved informasjonsdeling, og for å videreutvikle konseptet rundt informasjonsdeling. Deretter ble det benyttet et spørreskjema som ble sendt til leverandører, kunder, transportleverandør og en dagligvareaktør i en norsk dagligvarekjede for å innhente opplysninger om deres bruk av informasjonsdeling. Resultatet fra spørreundersøkelsen ble brukt til å vise anvendelsen av de identifiserte informasjonsdelingskarakteristikkene og deling av informasjon i dagligvarehandelen.

Avhandlingen inneholder i tillegg tre studier som undersøker de potensielle forbedringene ved å dele informasjon. Det ble gjennomført et multiple case study med 54 produkter i 21 butikker. Hensikten var å undersøke effekten av informasjonsdeling på matsvinn og produktenes ferskhetsgrad gjennom å sammenligne produkter bestilt med og uten (manuell bestilling) automatisk vareforsyning. Videre ble det utviklet en simuleringsmodell for å analysere effekten av informasjonsdeling ved automatisk vareforsyning og produktallokering for produkter med kort holdbarhet. Modellen simulerer butikker med forskjellige størrelser, profiler og leveringsfrekvenser. Modellen inneholder både kjente vareforsynings- og allokeringsprinsipper fra litteraturen og nye prinsipper som har blitt utviklet gjennom dette doktorgradsarbeidet.

For å besvare forskningsspørsmål 2 ble det undersøkt hvordan dagligvarekjeder planlegger stimulerende salgsaktivitet, i tillegg til hvordan *sales and operations planning* kan anvendes til dette formålet. En casestudie med en av Norges største dagligvarekjeder ble brukt for innledende kartlegging av problemstillingen, og senere utvidet til ytterligere casestudier i dagligvarekjeder i Norge, Storbritannia og en dagligvaregrossist i Finland, til sammen fire case.

Relatert til forskningsspørsmål 1 om informasjonsdeling, er de teoretiske bidragene fra doktorgradsarbeidet som følger:

- Identifisering og syntese av informasjonsaspektene ved delt informasjon, som kombinert med et utviklet kartleggingsverktøy for informasjonsdeling, bidrar til å spesifisere innholdet i informasjonen som deles i dagligvarekjeden.
- En empirisk vurdering av automatisk vareforsyning i forhold til manual vareforsyning. Analysen viste en reduksjon i matsvinn i gjennomsnitt på 17,8% for 54 produkter, og 5,2% forbedring i den vektede gjennomsnittlige gjenværende holdbarheten (ferskheten) for produktene i butikk. Resultatene indikerer også at den potensielle forbedringen er avhengig av produktets levetid.
- Et aldersbasert vareforsyningsprinsipp og to produktallokeringsprinsipper for produkter med kort holdbarhet. Basert på simulering av disse prinsippene viste resultatene følgende:
  - Økt bruk av informasjonsdeling i automatisk vareforsyning av produkter med holdbarhet mellom 4 og 11 dager kan i gjennomsnitt forbedre tilgjengeligheten av produkter med 10,3%, og redusere svinnet med 10,7%, mens det gjennomsnittlige lagernivået reduseres med 0,3%.
  - Bruk av informasjonsdeling for allokering av produkter med en holdbarhet på mellom 4 og 11 dager viste en forbedring på 3,3% av tilgjengeligheten, og 3,8% reduksjon i svinn. Disse resultatene er imidlertid også mulig å oppnå med informasjon som er innebygd i et tradisjonelt automatisk vareforsyningssystem, som betyr at det ikke er behov for ytterligere investeringer i datainnsamling.
  - Informasjonsdeling bør differensieres med hensyn til (minst) produktets levetid og leveringsfrekvensen til butikkene, for å oppnå store forbedringer.

De teoretiske bidragene relatert til forskningsspørsmål 2, om stimulerende salgsaktiviteter, kan oppsummeres slik:

- En foreslått *sales and operations planning* prosess tilpasset en situasjon med salgsfremmende tiltak, tilpasset egenskapene i dagligvarehandelen.
- Seks forslag til hvordan dagligvarekjedene kan forbedre planleggingen gjennom integrasjon mellom funksjoner, bruk av IT, dedikerte organisatoriske ressurser og ved å evaluere effekten av foregående salgsfremmende tiltak og bruke dette i fremtidige planleggingssykluser.

For praktikere i dagligvarehandelen har resultatene fra denne avhandlingen en rekke anvendelsesområder som kan oppsummeres i følgende anbefalinger:

- Bruken av informasjonsdeling er en kontinuerlig og iterativ prosess i dagligvarekjeden. Denne avhandlingen inneholder en oversikt over ulike aspekt, og et kartleggingsverktøy for å strukturere informasjonsdeling i forsyningskjeden. Det kan tydeliggjøre hvilken informasjon som blir brukt, hva som potensialt kan benyttes, og et forslag til hvordan dette knyttes til planleggingsprosesser.
  - Det er fordelaktig med differensiert informasjonsdeling og differensiering av de påfølgende planleggingsprosessene basert på produktegenskaper. For automatisk vareforsyning og produktallokering indikerer denne avhandlingen at deling og utnyttelse av salgs- og svinninformasjon kan forbedre forholdet mellom forsyning og etterspørsel. Deling av informasjon vedrørende gjenværende holdbarhet har størst effekt for produkter med en levetid på mellom 6 og 11 dager, og kan muliggjøre automatisk vareforsyning av disse produktene.

- Salgsfremmende tiltak er en viktig mekanisme i dagligvarehandelen, men tiltakene skaper også et høyt press på logistikk- og planleggingsfunksjonen. Effektene av salgstiltak bør gjenspeiles gjennom større fokus på å planlegge disse aktivitetene for å sikre koordinering på tvers av funksjoner. Denne avhandlingene inneholder en rekke forslag til hvordan man skaper et slikt fokus, og hvordan man strukturerer en taktisk planleggingsprosess som støtter salgsfremmende tiltak i dagligvarehandelen.

Denne doktorgradsavhandlingen har bidratt til å øke kunnskapen om hvordan dagligvarehandelen kan balansere forholdet mellom forsyning og etterspørsel. Konkret er effekten av automatisk vareforsyning og produktallokeringer undersøkt, men det er også demonstrert hvordan *sales and operations planning* kan være nyttig i dagligvarehandelen. Avhandlingen tilstreber å utvikle kunnskapsgrunnlaget og bidra til å forbedre dagligvarehandelen gjennom forslag til hvordan forsyning og etterspørsel kan balanseres.

Resumé

Formålet med at tilpasse forholdet mellem forsyning og efterspørgsel i dagligvarehandelen er at opnå tilgængelighed af produkter samtidig med at spild, transport, håndteringsomkostninger og lagerbeholdninger holdes på et minimum. Tilgængelighed defineres som at have et produkt i den ønskede form, smag, størrelse og kvalitet på det forventede sted (fra forbrugernes perspektiv) på hylden, når forbrugeren søger produktet (Aastrup og Kotzab, 2010; ECR, 2003). Sikring af høj tilgængelighed er nødvendig for at forblive konkurrencedygtig i dagligvarehandlen (ECR, 2003). Hvis produkterne ikke findes, kan forbrugerne skifte mærke eller butik, forlade butikken uden at købe noget, eller købe et substituerende produkt. Dette påvirker butikkens omdømme, omsætning og til sidst overskud. Dagligvareforhandlere kan ikke opnå denne høje tilgængelighed ved blot at overfylde deres hylder med produkter, da usolgte produkter vil ende som spild, hvis de ikke sælges i tide. I dag spildes der mad nok langs forsyningskæden til at kunne mætte en milliard mennesker (Kummu et al., 2012). Størrelsen af problemet er bemærkelsesværdigt og selv små forbedringer kan have en betydelig indflydelse, og dagligvareforhandlere bør derfor tilstræbe at tilpasse forholdet mellem deres forsyning og efterspørgsel (Beddington, 2011).

Denne PhD-afhandling undersøger, hvordan dagligvareforhandlere kan tilpasse forholdet mellem forsyning og efterspørgsel gennem forbedret beslutningstagning i deres planlægningsprocesser. To underliggende hypoteser er at "*informationsdeling kan reducere usikkerheder og forbedre match mellem forsyning og efterspørgsel* [frit oversat]" (Ketzenberg et al., 2007, s. 1236) og at "*forbedret gennemsigtighed af efterspørgselsinformation i forsyningskæden (…) kan reducere spildet igennem kæden* [frit oversat]" (Mena et al., 2014, s. 152). Ved at kombinere disse to hypoteser forventes det, at informationsdeling har evnen til at forbedre tilpasningen mellem forsyning og efterspørgsel, som vil blive synliggjort ved en forbedret tilgængelighed og et reduceret spild.

Det teoretiske fundament i afhandlingen er positioneret i Operations Management og centrerer sig omkring informationsdeling, automatisk genopfyldning og *sales and operations planning*. Informationsdeling er ofte fremhævet som værende et at de mest markante midler for at koordinere forsyningskæden (Arshinder et al., 2008) og herigennem styrke præstationsevnen (Baihaqi and Sohal, 2013; Barratt and Oke, 2007; Myrelid, 2015; Sezen, 2008). Informationsudnyttelses-konceptet (Jonsson og Myrelid, 2016; Myrelid, 2015) understreger, at delt information skal indarbejdes i modtagerens processer, før informationen kan skabe værdi for modtageren og resten af forsyningskæden. Informationsudnyttelseskonceptet er dog stadig under udvikling, og hvordan delt information karakteriseres og forbindes til planlægningsprocesser er fortsat et åbent spørgsmål.

Informationsdeling anvendes ofte i dagligvarehandlen gennem automatisk genopfyldning, som stammer fra Efficient Consumer Response, der blev introduceret i starten af 90-erne (Salmon, 1993). Automatisk genopfyldning fungerer ved at generere ordrer (forslag) baseret på information om salgs og spild fra butikker, og har været en populær metode til at forbedre tilgængeligheden. Anvendelsen af informationsdeling og automatisk genopfyldning til reduktion af madspild samt anvendelighed for af dette produkter for med en kort holdbarhed er imidlertid ikke tilstrækkeligt dækket i den nuværende akademiske litteratur. Som hovedemne har denne afhandling derfor følgende forskningsspørgsmål:

1. Hvordan bidrager informationsdeling til at tilpasse forholdet mellem salg og leverancer i dagligvarehandel?
    a. Hvordan kan informationsdeling karakteriseres for dagligvarehandel?
    b. Hvad er effekten af informationsdeling for dagligvarehandel?

Efficient Consumer Response omfatter også initiativer for at styre tilbudsvarer og produkt introduktioner, som primært bruges til at stimulere salg i butikkerne. Stimulerede salg er i dag dog stadig en af de sværeste opgaver at styre for dagligvarekæderne (Martec, 2017; Moussaoui et al., 2016). På grund af de ofte meget store salgsmængder har stimulerende salgsaktiviteter en stor påvirkning på den bagvedliggende logistik og planlægning. Det er derfor også typisk at starte planlægningen af hele forsyningskæden flere måneder i forvejen for at sikre tilgængelighed af produkterne.

I *sales and operations planning* er tankesættet at man planlægger på tværs af organisationens funktioner (og i nogle tilfælde hele forsyningskæden) for aktiviteter som kræver lang forberedelse, eks. ekstra bemanding, lageropbygning eller allokering af produkter mellem fabrikker og lagre (Jacobs et al., 2011; Thomé et al., 2012). Brugen af *sales and operations planning* Planning til at styre salgsstimulerende aktiviteter i dagligvarekæder virker derfor fristende, men har aldrig været undersøgt i den akademiske litteratur. Som et sekundært emne undersøger denne afhandling derfor:

2. Hvordan tilpasses forholdet mellem forsyning og efterspørgsel effektivt i dagligvarehandel for stimulerede salgsaktiviteter?

For at besvare forskningsspørgsmål 1 blev der udført to litteraturstudier for at identificere karakteristerne ved informationsdeling samt for at videreudvikle informationsudnyttelses-konceptet. Herefter blev et spørgeskema sendt til leverandører, kunder, transportudbydere og dagligvareforhandleren i en norsk fødevarekæde for at forstå deres brug af informationsdeling. Resultatet fra spørgeskemaet blev brugt til at demonstrere anvendeligheden og af de identificerede karakteristikker af informationsdeling samt informationsudnyttelseskonceptet i dagligvarehandel.

Derudover indeholder afhandlingen tre studier, der undersøger den potentielle forbedring ved brugen af informationsdeling. Der blev gennemført et multiple case study med adgang til 54 produkter på tværs af 21 butikker for at undersøge effekten på madspild og friskhed af produkter i butikkerne ved at sammenligne automatisk genopfyldning med manuel genopfyldning. Derforuden blev der opbygget en simuleringsmodel til at vurdere effekten af informationsdeling for automatisk genopfyldning og produkt allokering for produkter med kort holdbarhed. Modellen simulerer aftræksmønsteret for ét produkt i en divergerende forsyningskæde med ét lager, der leverer til 232 butikker i forskellige størrelser, profiler og leveringsfrekvenser. Modellen indeholder både kendte genopfyldnings- og allokerings principper fra litteraturen samt nye principper, som er blevet udviklet som led i dette PhD arbejde.

For forskningsspørgsmål 2 blev det undersøgt hvordan dagligvareforhandlere planlagde stimulerede salgsaktiviteter, samt hvordan *sales and operations planning* kunne anvendes til dette formål. Et casestudie med en af Norges største dagligvareforhandlere blev brugt til at danne en første forståelse, og blev senere udvidet til et multiple case study som inkluderede en anden dagligvareforhandler fra Norge, én fra Storbritannien og én grossist fra Finland.

De teoretiske bidrag fra forskningsspørgsmål 1, med hensyn til informationsdeling, kan sammenfattes til:

- Identifikation og syntese af informationsfacetter til karakterisering af delt information, som kombineret med et foreslået kortlægningsværktøj til informationsdeling bidrager til udviklingen af informationsudnyttelseskonceptet i dagligvarehandel.
- En empirisk evaluering af automatisk genopfyldning i forhold til manual genopfyldning. Resultaterne viste et gennemsnit på 17,8% reduktion i madspild på tværs af 54 produkter og 5,2% forbedring i den vægtede gennemsnitlige tilbageværende holdbarhed (friskhed) af produkterne i butikkerne. Resultaterne indikerede også, at den potentielle forbedring er afhængig af produktets levetid.
- Et genopfyldningsprincip baseret på produkterne friskhed og to produkt allokeringsprincipper for produkter med kort holdbarhed. Baseret på simulering af disse viste resultaterne at:
    - Brug af øget informationsdeling til automatisk genopfyldning af produkter med en holdbarhed på mellem 4 og 11 dage kan i gennemsnit forbedre tilgængeligheden med 10,3% og reducere spildet med 10,7%, mens det gennemsnitlige lagerniveau sænkes med 0,3%.
    - Brug af informationsdeling for allokering af produkter med en holdbarhed på mellem 4 og 11 dage viste en 3,3% forbedring af tilgængeligheden og 3,8% reduktion i spild. Disse resultater er imidlertid mulige at opnå med information, der allerede er indlejret i et traditionelt automatisk genopfyldningssystem, hvilket betyder, at der ikke er behov for yderligere investeringer i dataindsamling.
    - Informationsdeling bør differentieres ud fra (som minimum) produktets levetid og leveringsfrekvensen til butikkerne for at opnå de største forbedringer ved informationsdeling.

De teoretiske bidrag fra forskningsspørgsmål 2, med hensyn til stimulerende salgsaktiviteter, kan sammenfattes til:

- En foreslået *sales and operations planning* proces tilpasset styring af stimulerende salgsaktiviteter og som tager højde for egenskaberne i dagligvarehandelen.
- Seks forslag til hvordan dagligvareforhandlere kan forbedre deres tværfunktionelle planlægning ved hjælp af IT, dedikerede organisatoriske ressourcer og ved at evaluere effekten af foregående stimulerede salgsaktiviteter og bruge dette i fremtidige planlægningscyklusser

For praktikere i dagligvarehandel har resultaterne og bidragene fra denne afhandling en række anvendelsesområder og kan opsummeres til følgende anbefalinger:

- Brugen af informationsdeling er en kontinuerlig og iterativ proces. Denne afhandling inkluderer en liste over facetter og et kortlægningsværktøj til at strukturere informationsdeling i forsyningskæden. Dette kan give en visualisering af, hvilke informationer der på nuværende tidspunkt anvendes, hvad der potentielt kunne anvendes, samt forslag til hvordan man forbinder delt information til planlægningsprocesser.
- Differentieret informationsdeling og differencering af de efterfølgende planlægningsprocesser baseret på produktegenskaber er fordelagtigt. For automatisk genopfyldning og produkt allokering indikerer denne afhandling at deling og udnyttelse af salgs og spild information kan forbedre balancen mellem forsyning og efterspørgsel. Deling af information omkring tilbageværende holdbarhed har størst effekt for produkter med en levetid på mellem 6 og 11 dage, og kan muliggøre automatisk genopfyldning af disse produkter.

- Stimulerende salgsaktiviteter udgør en vigtig andel af den samlede omsætning, men skaber også et stort pres på den underliggende logistik og planlægning. Denne vigtighed bør derfor også afspejles med et større fokus på at planlægge disse aktiviteter for at sikre koordinering på tværs af funktionerne i virksomheden. Denne afhandling indeholder en række forslag til, hvordan man skaber et sådan fokus og hvordan man strukturerer en taktisk planlægningsproces som understøtter stimulerende salgsaktiviteter i dagligvarehandel.

Samlet bidrager denne PhD afhandling til en række anvisninger til hvordan dagligvareforhandlere kan tilpasse forholdet mellem forsyning og efterspørgsel. Konkret er effekten af automatisk genopfyldning og produkt allokeringer undersøgt, men det er også demonstreret, hvordan *sales and operations planning* kan være nyttig i dagligvarehandel. Afhandlingen stræber efter at understøtte fremtidige diskussioner og den videre udvikling af dagligvarehandel ved at fremhæve nogle af mulighederne for at tilpasse forholdet mellem forsyning og efterspørgsel.

Abbreviations

CPFR	Collaborative Planning Forecasting and Replenishment
CRP	Continuous Replenishment Program
CV	Coefficient of Variation (standard deviation compared to the mean)
ECR	Efficient Consumer Response
EDI	Electronic Data Interchange
EWA	Not an abbreviation, but the name of an inventory policy
EWA_{SS}	Modified version of the EWA policy
FIFO	First In First Out (stock depletion)
LIFO	Last In Last Out (stock depletion)
OIR	Old Inventory Ratio (an inventory policy)
POS	Point of Sales
QA	Quantity Allocated
RDSCP	Retail Demand and Supply Chain Planning
RQ	Research Question
RSL	Remaining Shelf Life
S&OP	Sales and Operations Planning
SCOR	Supply Chain Operations Reference
SKU	Stock Keeping Unit
SS	Safety Stock
VMI	Vendor Managed Inventory

List of Appended Papers

Paper #1
Kiil, K., Dreyer, H.C., Hvolby H.H. (2015) Linking Information Exchange to Planning and Control: An Overview. *Advances in Production Management Systems: Innovative Production Management Towards Sustainable Growth. 5-9 September 2015, Tokyo, Japan.*

Paper #2
Kiil, K., Hvolby H.H., Trienekens, J., Behdani, B., Strandhagen, J.O. (Forthcoming) From Information sharing to Information Utilization in Food Supply Chains. *International Journal of Information Systems and Supply Chain Management.* Accepted. Will be printed August 2018.

Paper #3
Kiil, K., Dreyer, H.C., Hvolby H.H., Chabada, L. (2018) Sustainable Food Supply Chains: The Impact of Automatic Replenishment in Grocery Stores. *Production Planning and Control*. Volume 29, issue 2, pp. 106-116

Paper #4
Kiil, K., Hvolby H.H., Fraser, K., Dreyer, H.C., Strandhagen, J.O. (In review) Automatic replenishment of perishables in grocery retailing: The value of utilizing remaining shelf life information. *British Food Journal*. Submitted for first review October 2017.

Paper #5
Kiil, K., Hvolby H.H., Dreyer, H.C., Strandhagen, J.O.. (2017) Inventory Allocation of Perishables: Guidelines. *Advances in Production Management Systems: The Path to Intelligent, Collaborative and Sustainable Manufacturing. 3-7 September 2017, Hamburg, Germany*.

Paper #6
Dreyer, H.C., Dukovska-Popovska, I., Kiil, K., Kaipia, R., (2016) Retail Tactical Planning: An Aligned Process? *Advances in Production Management Systems: Production Management Initiatives for a Sustainable World. 3-7 September 2016, Iguassu Falls, Brazil.*

Paper #7
Dreyer, H.C., Kiil, K., Dukovska-Popovska, I., Kaipia, R. (In review) Enhancing tactical planning in grocery retailing with S&OP. *International Journal of Physical Distribution and Logistics Management.* Submitted for 3rd review October 2017.

Table of Contents

Introduction 1

The aim of aligning supply and demand is to achieve availability of products while keeping waste, transportation, handling cost, and inventory levels at a minimum. This chapter outlines the motivation for studying this topic by firstly clarifying the importance of grocery retailing in today's food supply chains and, secondly, presenting the challenges it faces. Afterwards, the research objective and corresponding research questions are specified together with a delimitation of the scope.

1.1. The Importance of Grocery Retailing

Convenient and sustainable conveying of food from producers to consumers has changed considerably during the last decades, and more changes are still to come. The formation of large retailers owning one or several stores concepts, warehouses, distribution centers, and private labels has gained tremendous market share, and today the main part of all food products are sold through grocery retailers. Retailers may even offer a wide range of store concepts to compete for both the discount and premium sector and thereby increasing the total volume through its distribution centers. Other noteworthy sales channels from Figure 1.1 are farmers market and online retailing. Farmers markets are often associated with local high-quality artisan products, but their market share of 3.8% together with specialty shops may indicate that consumers do not undertake their everyday shopping there but mostly search for special type of products. Online retailing is gaining momentum and is currently experiencing a significant growth (Trienekens et al., 2017). However, as illustrated in Figure 1.1 grocery retailing is still the predominant channel with 94.1% of the all products being sold there (including grocery and discount stores). Due to its size, and impact, this PhD study focuses on grocery retailing, which can be defined as:

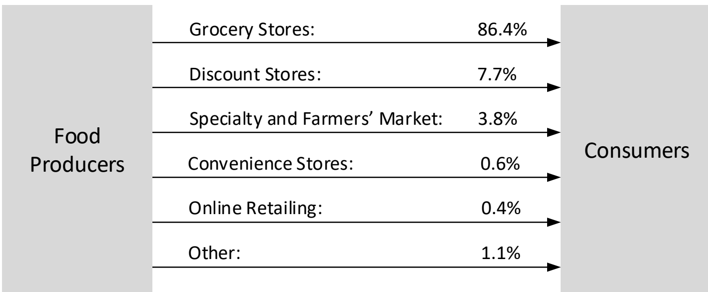

Figure 1.1: Major sales channels' market share of groceries (NGA, 2015)

> *the final activities needed to place a food product in the hand of the consumer. These activities may take place at a wholesaler, warehouse or distribution center, a store, or in between these entities* (based on Goworek and McGoldrick (2015); Sternbeck and Kuhn (2014)).

1.2. Characteristics of Grocery Retailing

The characteristics of grocery retailing place specific requirements on the logistical operations and questions the applicability of traditional supply chain practices (Blackburn and Scudder, 2009; Soysal et al., 2012). This section outlines these characteristics and discusses the implications on the supply chain.

One of the driving sources which separate and complicates grocery retailing (and food supply chains) compared to other industries is the perishability of the products (Fredriksson and Liljestrand, 2015; Romsdal, 2014; Van der Vorst et al., 2009). In other words, the quality and safety, of the products change with certain rates depending on the product – which in turn has propelled several initiatives to extend and manage this quality (Trienekens et al., 2012; Van der Vorst et al., 2009). E.g., strawberries at room temperature may last for some days if they are chilled down it may last up to a week, and if they are frozen more than a year. To accomplish this, it places a direct requirement to control the temperature through the whole supply chain. Thus, special logistical requirements are needed in grocery retailing compared to other industries (Fredriksson and Liljestrand, 2015; Van der Vorst et al., 2005).

Even though perishability is controlled and the shelf life is extended to a week by chilling, requirements to a high delivery frequency is still necessary to avoid undersupply and because the use of buffer inventories is limited for products with a short shelf life (Ahumada and Villalobos, 2009). On the other hand, in case of oversupply to the stores, the use of mark-downs strategy is often used to stimulate demand and avoid food waste (Hübner et al., 2013).

The coordination of products is further complicated due to the existence of both supply and demand uncertainty (Romsdal, 2014; Singh, 2014; Taylor and Fearne, 2009). Production of agricultural products such as fruit, vegetables, and meat is subject to long throughput times and the exact day, volume, and quality might only be observable at the very end. Additionally, these products might be subjected to seasonality, and the quality or availability of those products are not consistent throughout the year (Romsdal, 2014). Regarding uncertainty in demand; sales in stores have been reported to fluctuate ± 11% around the mean, while it fluctuates up to 115% at the producer (Taylor and Fearne, 2009). This clearly demonstrates the existence of demand amplification and a possibility to improve the inter-organizational coordination of supply and demand.

Traceability requirements have been mandatory for companies operating in food supply chains for several years (Trienekens and van Der Vorst, 2006). Traceability can be understood as "*the ability to determine the on-going location of products and to trace products back to their origin and used production method*" (Trienekens et al., 2014, p. 499). The main purpose and legal argument for implementing a traceability system is to ensure public food safety and the ability to take prompt actions if required (Thakur et al., 2011; Trienekens and van Der Vorst, 2006).

1.3. Challenges in Grocery Retailing and Motivation for this Study

With more than 40 years of "out-of-stock" research in retailing on-shelf-availability remains a struggle and a major importance of today's retailers (Aastrup and Kotzab, 2010; Dani, 2015; Fernie and Sparks, 2009; Moussaoui et al., 2016). This is not only true in the academic literature, but industry surveys continuously echoed this result year after year (Martec, 2015, 2016, 2017). Availability refers to having a product in its desired form, flavor, size, and saleable condition in the expected location (from the consumers perspective) in stock when the consumer reaches for the product (Aastrup and Kotzab, 2010; ECR, 2003). Of course, availability itself is not the problem but merely a symptom which manifests the underlying challenges in grocery retailing (Moussaoui et al., 2016). Increasing availability is "straightforward" if other cost aspects are ignored.

The underlying challenges relate to the balance of availability on one side and other cost aspects, such as e.g. transportation, inventory holding cost, products being wasted, and handling costs, on the other side. Subsequently, there is a challenge and a need to align supply and demand sustainably in grocery retailing (Beddington, 2011; Mena et al., 2014; Wognum et al., 2011). The availability of products in stores is estimated to range from 93.8% to 96.8% indicating a deficit of supply (Aastrup and Kotzab, 2009), while estimates of food waste along the supply chain ranges from 25% to 35% indicating a surplus of supply (Kummu et al., 2012; Parfitt et al., 2010).

Recent changes and trends in consumer behavior have intensified the retailer's need to align supply and demand (Fernie and Sparks, 2009). Firstly, retailers are currently experiencing a decreasing footfall (number of customers and time spent in the store) (Dani, 2015; Tugby, 2016), and a 1.2% year-to-year decrease is expected to happen (Richardson, 2016). The footfall might be caused by increasing online shopping (Samuel, 2017). Secondly, a clear tendency is that consumers demand more fresh and short shelf life products – which currently account for 25% of the total grocery sales and 35% of the growth (Nielsen, 2016b). An increased demand for healthy ready-to-eat products, such as fresh salads, soups, sandwiches, and meal-kits has already started and is expected to continue (Dani, 2015; Nielsen, 2016b). Hence, consumers also increasing expects products to be fresh with a long remaining shelf life (Fernie and Sparks, 2009; Hübner et al., 2013).

To maintain footfall, grocery retailers are using both traditional initiatives, such as promotions, and experimenting with serval new initiatives (known as retailtainment) to attract consumers to the stores (Dani, 2015; Vend, 2016). These stimulating activities highly affect demand and subsequently how grocery retailers are supplied. Figure 1.2 illustrates the fluctuations of ingoing products (created by stimulated demand activities) in grocery retailing.

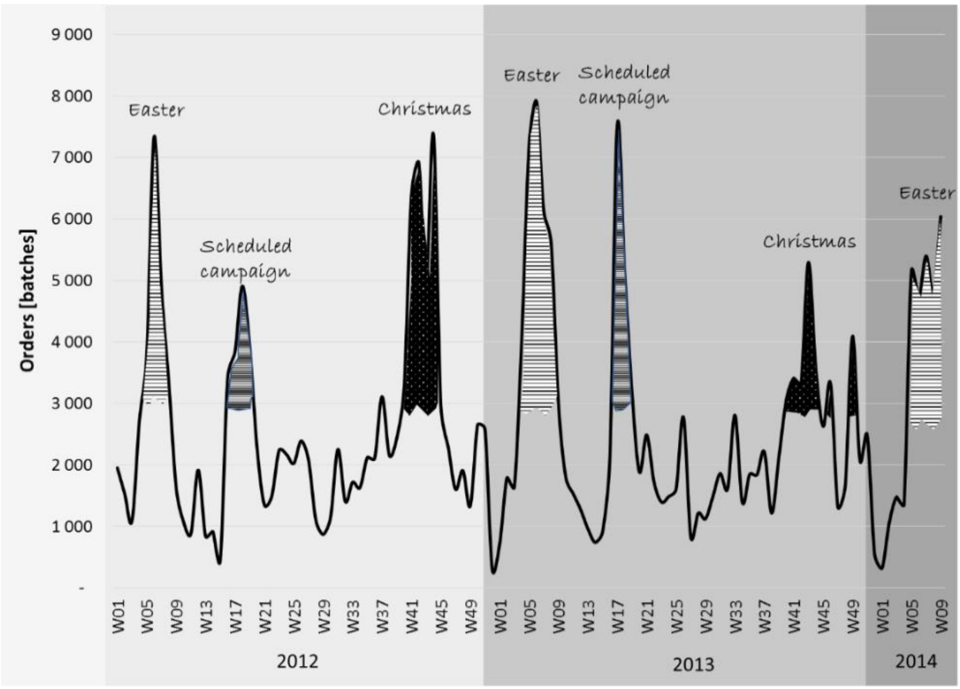

Figure 1.2: Fluctuation in orders for candy. Demonstrating stable and stimulated demand (Brynild, 2017)

Demand may be stimulated through changes in the assortment, price, or both at the same time (Hübner et al., 2013). Figure 1.3 provides an overview of these activities and illustrates the two predominant demand types in grocery retailing, which in this thesis referred to as stimulated and stable demand.

Price	*Permanent*	*Temporary*
Normal	Stable	Stimulated
Reduced	Stimulated	Stimulated

Assortment

Figure 1.3: Stable and stimulated demand in grocery retailing

The demand-stimulating activities often overlap, e.g. new or seasonal products are introduced together with a promotion and complicates the logistical operations even further (Ettouzani et al., 2012; Fernie and Sparks, 2009). The result is often a more volatile demand pattern (Gedenk et al., 2010; Huchzermeier and Iyer, 2010), which in grocery retailing appears to be notoriously difficult to manage (Ettouzani et al., 2012; Gruen et al., 2002). Poor handling of stimulated demand is also clearly reflected in an out-of-stock situation 11% of the time compared to 4% for stable demand (Ettouzani et al., 2012).

Apart from stimulated demand Fernie and Sparks (2009, p. 7) notice that "*at the same time they [grocery retailers] need to move less demand-volatile products in an efficient and cost-effective manner*." Consequently, grocery retailer has during the last two decades grown both vertically and horizontally to achieve economy of scale and encompass more functions (Hendrickson et al., 2001; Hübner et al., 2013; van Donk et al., 2008). Traditionally, these large-scaled and large-volume facilities are characterized by a low unit cost on the expense of a low flexibility, but particularly suited for products with a rather stable demand (Hayes and Wheelwright, 1979).

Thus, on one hand, there is a need to effectively manage products with a stimulated demand because of its large impact on the supply chain. On the other hand, there is a need to increase efficiency for products facing stable demand by e.g. reducing inventories and automating trivial processes (Van Donselaar et al., 2010). Because of the differences (as highlighted in Figure 1.2) between two demand types, it is also suggested to treat them separately (Fisher, 1997; Småros, 2017). However, the aim is the same: achieve high availability of products while keeping waste, transportation, handling cost, and inventory levels at a minimum.

Current concepts, such as efficient consumer response with initiatives as 'efficient product introductions' and 'efficient promotions' has been proposed to handle the stimulated demand (Reyes and Bhutta, 2005). While information sharing and automatic replenishment systems have been suggested to improve the replenishment process of products with stable demand (Van Donselaar et al., 2010). However, handling stimulated demand is still one of the main challenges for grocery retailers (Ettouzani et al., 2012; Martec, 2017) and automatic replenishment systems are e.g. not designed for perishables with short shelf life which is increasingly gaining market importance (Van Donselaar et al., 2006; Van Donselaar et al., 2010).

1.4. Research Objective

The objective of this PhD research is to contribute to how grocery retailers can align supply and demand through improved decision making in their planning processes. Based on the introduction of the challenges in grocery retailing this objective is further specified into two research questions. One for each of two demand types from Figure 1.3.

As highlighted by Fernie and Sparks (2009) grocery retailers need to manage stable demand products in an efficient manner. Information sharing and the use of automatic replenishment systems have been developed and implemented to support this purpose – this thesis continues this development. Specifically, information sharing has been shown to be a valuable remedy for improving availability and has also been proposed to comprehend additional improvements such as reduce food waste across the supply chain, but the actual size of this improvement remains an open question (Kaipia et al., 2013; Mena et al., 2011; Mena et al., 2014; Taylor and Fearne, 2009). Additionally, information sharing is currently mainly used for replenishment decisions and for products with a long shelf life (Potter and Disney, 2010; Van Donselaar et al., 2010). Thus, to adequately understand information sharing and evaluate how it can improve decision making, and its subsequent impact on alignment, a set of questions has been put forward to guide the research:

Research Question 1:

How does information sharing contribute to align supply and demand in grocery retailing?

a. How is information sharing characterized in grocery retailing?
b. What is the impact of information sharing in grocery retailing?

Secondly, it appears that the demand stimulating activities such as reduced prices, product introductions, and similar activities from Figure 1.3 are put in place to attract consumers into the store (Gedenk et al., 2010; Huchzermeier and Iyer, 2010). However, at the same time, the rather poor realization of these activities with an 11% out-of-stock situation (Ettouzani et al., 2012) indicates that previous practices are not providing a satisfactory performance. This indicates a need to examine this topic of stimulated demand activities further. Hence, as a *subordinate* topic in this thesis research question 2 was put forward:

Research Question 2:

How do grocery retailers effectively align supply and stimulated demand?

1.5. Scope

Even though the research questions help specify the direction of the research the research needs a further positioning within the existing literature streams and terminologies. The selection and specifications of research scope were made collectively with the involved case companies (these will be presented in Chapter 3).

Regarding research question 1; behavioral, technical, and ethical aspects are not considered as subjects for this study. This include the trust and willingness (Fawcett et al., 2007; Fawcett et al., 2009) necessary for companies to engage in information sharing activities, as well as the technology needed to capture data and the rightfulness of sharing personal or near-personal information for business purposes. Lastly, information quality, even though it relates to information sharing (Myrelid, 2015), it is in this study perceived as a literature stream of its own (see e.g. (Gustavsson and Wänström, 2009; Lee et al., 2002)) and is thus not explicitly considered but information is assumed to be of high quality.

For research question 2; demand literature streams with a clear marketing-oriented perspective (develop promotions, how to develop new products based on consumer preferences, consumer loyalty, etc.) do not fall within the scope of this study, as the objective of the research is to *align* supply and demand.

This study is concerned with research and literature discussing planning within grocery retailing and particularly for improving the flow of goods and utilization of the reversed information flow. Examples of such literature streams include (perishable) inventory management, value of information, and sales and operations planning. Additionally, the conducted studies apply a process perspective (Slack et al., 2007). I.e., this is the fundamental lens when approaching, analyzing, and making suggestions to observed gaps in literature and practice.

1.6. Thesis Outline

The thesis is based on the research that has been conducted and documented in the seven appended papers and serves the purpose of synthesizing and presenting these results. The thesis is intended to be read and understood without reading the appended papers, however when appropriate a reference to the specific paper is made to clarify details.

The remainder of this thesis is structured around five chapters discussing: (2) the theoretical background, (3) research design, (4 and 5) findings and discussion, and (6) conclusions. Some chapters include a section which is dedicated to each research question, and Table 1.1 highlights the most essential sections and chapters if the thesis is to be read individually according to the two research questions.

Table 1.1 Essential sections according to the two research questions

	Research Question 1	**Research Question 2**
Theoretical Background	Section 2.2	Section 2.3
Research Design	Section 3.1.1	Section 3.1.2
Findings and Discussion	Chapter 4	Chapter 5
Conclusion	Section 6.1	Section 6.1
Appended Papers	*1-5*	*6-7*

Theoretical Background 2

The relevant literature has been carefully examined either before or in parallel with the initial phase of each sub-study. This helped ensure theoretical relevance and positioning of the work. Accordingly, this chapter serves the purpose of outlining the theoretical foundation and is divided into five major sections. First, there is a general introduction to planning in retailing, which includes the most relevant industry terms. The second section presents the theoretical background related to research question 1. Especially, attention is paid to the replenishment and inventory allocation between a warehouse and stores. These two decisions are selected as a primary focus point in the thesis because they are expected to have a direct impact on the alignment between supply and demand. The replenishment decision controls the timing and the quantity of products delivered to the stores – this timing and quantity should be synchronized to when the demand is happening to ensure high availability on one hand and low waste on the other. The inventory allocation controls which store that receive oldest and newest products (from the warehouse) to reduce this risk of products expiring in the store. Similarly, the inventory allocation also controls how many products each store should receive, in case of stock-out at the warehouse, to ensure the highest possible demand is fulfilled. For both the replenishment and the inventory allocation special devotion is paid to products with a short shelf life, as these are becoming increasingly important for grocery retailers and are known to have higher waste levels (Kaipia et al., 2013).

The third section presents the theoretical background related to research question 2. Specifically, it is presented how planning for stimulated demand activities has evolved since the early nineties and why sales and operations planning (from the manufacturing domain) could be the future step in this development. Sales and operations planning is a tactical planning process which seeks to balance supply and demand on a volume level – this purpose is considered to support the overall objective of aligning supply and demand and resonates why it has been selected as part of this thesis.

To compare possible scenarios and adequately discuss performance the fourth section outlines relevant performance measures for grocery retailing. Lastly, the final section summarizes the presented literature into a research framework and places it in relation to the research questions.

2.1. Planning Frameworks in Grocery Retailing

At least three planning frameworks exist for a general introduction to planning in grocery retailing. They are the Supply Chain Operation Reference (SCOR) model (SCC, 2012), Efficient Consumer Response (ECR) (Salmon, 1993), and the Retail Demand and Supply Chain Planning (RDSCP) Framework (Hübner et al., 2013).

The SCOR model provides a generic understanding of supply chains and includes specific processes for the retail industry (SCC, 2012). Even though it is popular in both industry and academia, it is a tool developed for diagnostic and benchmarking purposes (as demonstrated in Paper #4) (Ntabe et al., 2015). Its main strength lays in providing a standardized overview of material flow and decision processes for the purpose of comparison. However, because a SCOR flow chart of retailing would be either too detailed or too aggregated it is not considered adequate at this point.

ECR consist of four main strategies that all seek to increase collaboration across the supply chain (Kotzab, 1999). They are (1) efficient store assortment, (2) efficient promotions, (3) efficient product introductions, and (4) efficient replenishment (Salmon, 1993). Individually, the four strategies are useful and will be considered in section 2.2 and 2.3, but overall ECR does not provide a comprehensive overview of the planning tasks found in grocery retailing (Hübner et al., 2013). ECR has later evolved into collaborative planning forecasting and replenishment (CPFR) (Barratt and Oliveira, 2001).

The RDSCP framework is useful for a general introduction to planning in grocery retailing. It is a natural adaptation of the supply chain planning matrix developed to support advanced planning systems (Fleischmann and Meyr, 2003; Stadtler, 2005). Vertically the decisions are based on the principles of hierarchical planning ranging from aggregated and long-term down to detailed short-term decisions. Horizontally, the matrix follows the material flow starting with purchasing and ending with sales (Stadtler, 2005).

2.1.1. Retail Demand and Supply Chain Planning Framework

Figure 2.1 illustrates the adapted supply chain planning matrix for grocery retailing, namely the RDSCP framework. It has been solidly verified with interviews and observations across 28 retailers in Europe (Hübner et al., 2013). The main adaptation to this context is horizontally where the decisions they are grouped according to the functions in retailing. For example, warehousing has replaced operations from the traditional supply chain planning matrix, and master category planning has replaced demand planning. The following subsections briefly go through each of the hierarchical levels of the RDSCP framework and afterward a comparison with ECR.

Long-term configuration planning

The long-term configuration is not only limited to the network design (i.e. the location, size, and type of warehouse(s) and stores) but also includes the strategies for physical distribution, technology selection, as well as sourcing and supplier selection (Hübner et al., 2013). The increasing expansion of the number of retail formats or retail chains and vitality of store locations emphasizes the complexity and importance of an adequate network design (Gill and Ishaq Bhatti, 2007; Kabadayi et al., 2007). The physical distribution structure entails the decision of direct delivery to stores from suppliers, cross-docking, through the warehouse, or some other combination (Akkerman et al., 2010; Kuhn and Sternbeck, 2013). Technology selection is typically a central element of the warehouse design, e.g. deciding the technology for the pick-and-pack process of ambient, chilled, and frozen products (De Koster et al., 2007; Gu et al., 2007). The sourcing strategy specifies the number of suppliers per category, the use of branded or private labels, while supplier selection and contracting include pricing, delivery terms, yearly volumes agreements (Hübner et al., 2013).

Mid-term master planning

Mid-term master planning generally covers planning decisions 6-12 months in advance and constitutes of six major areas as illustrated in Figure 2.1. (1) Product segmentation and allocation form adequate product groups based on sales patterns, service level, and others logistical factors. Detailed distribution structure, transportation means, and warehouse allocation(s) are afterward allocated for these groups. Also, determination of dispatch units and product carries (roll-cages, returnable boxes, etc.) fall within this area. (2) Inbound planning relates to the calculation of reorder points, order quantities, and, if the retailer participates in the transportation planning, establishment of the inbound route plan to balance stock-outs, waste, handling costs, and limited space in stores and warehouses (Ganeshan, 1999). (3) Production planning is mainly concerned with the internal design of the warehouse (Gu et al., 2007), and alignment of warehouse personnel according to the expected demand. (4) Distribution planning determines the ordering rules for stores and corresponding planning of transportation to achieve a high service level at the store, minimum waste, and a high utilization of trucks (Rushton et al., 2014). (5) Master category planning identifies the categories to be listed, and the underlying assortment planning disaggregates this further, while space management develops planograms (specifies the number of facings and location on the shelf) (Hübner and Kuhn, 2012). Promotion planning – deciding the type of promotion, the assortment, and pricing – is also part of master category planning. (6) In-store planning addresses the personnel requirements according to expected demand, and initiatives for improving the in-store logistics (Curşeu et al., 2009).

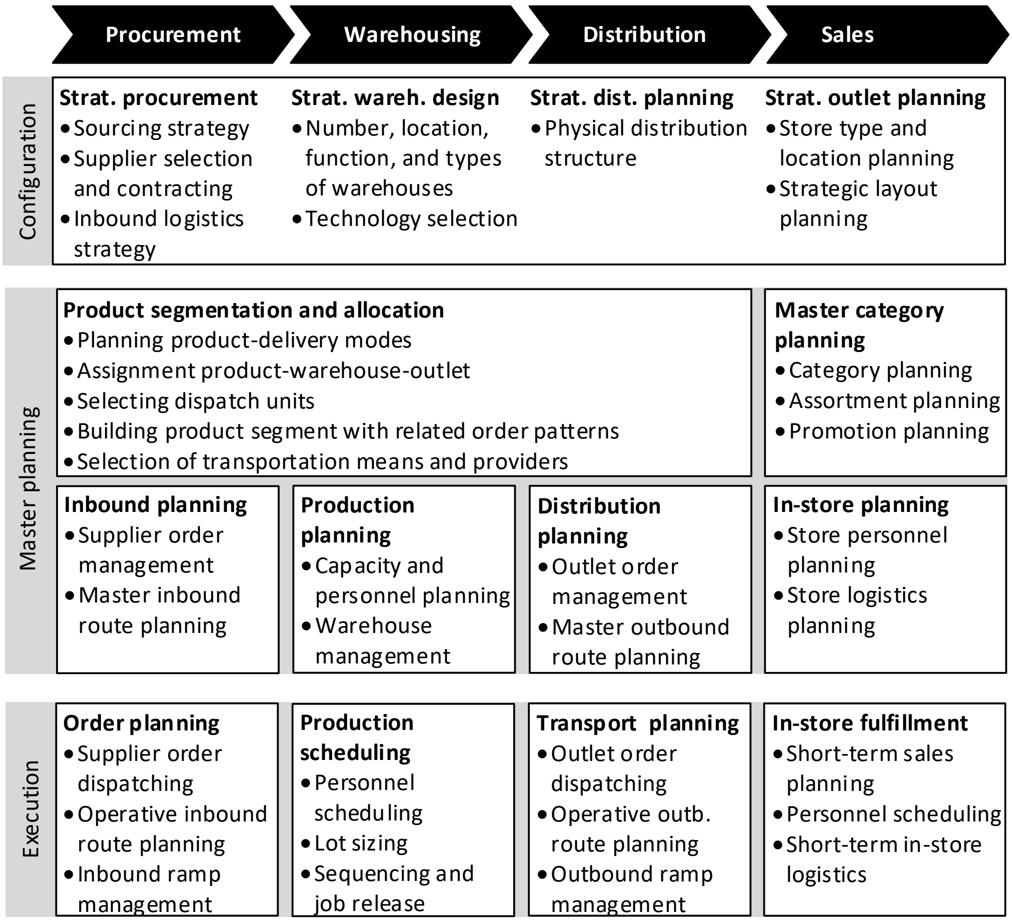

Figure 2.1: Retail Demand and Supply Chain Planning framework (Hübner et al., 2013)

Short-term execution planning

Short-term execution planning covers the hourly to weekly planning activities and is centered around four main areas as illustrated in Figure 2.1. (1) Order planning entails the short-term question of when and how much to order, based on the selected inventory policy in the superior planning level. Also, the allocation of trucks and time-phase deployment for the timing of pick-ups is part of this planning area. (2) Production scheduling is the short-term adjustment of warehouse personnel as well as the release of picking orders. (3) Transport planning is the development of a time-phase route plan for outbound transportation between the warehouse and stores, as well as the allocation of trucks and drivers for the individual orders. (4) In-store fulfillment is concerned with forecasting and replenishment of the individual product, restocking of shelves, mark-down of products with limited remaining shelf life, and short-term adjustment of store personnel (Kabak et al., 2008; Kotzab and Teller, 2005).

2.1.2. Efficient Consumer Response

ECR contains a vision of suppliers, distributors, and grocery retailers working closely together (Salmon, 1993), but in practice it merely appears as a collection of different strategies for planning in grocery retailing (Kotzab, 1999). Figure 2.2 illustrates how the four ECR strategies relate to the planning decisions in the RDSCP framework introduced in the section above.

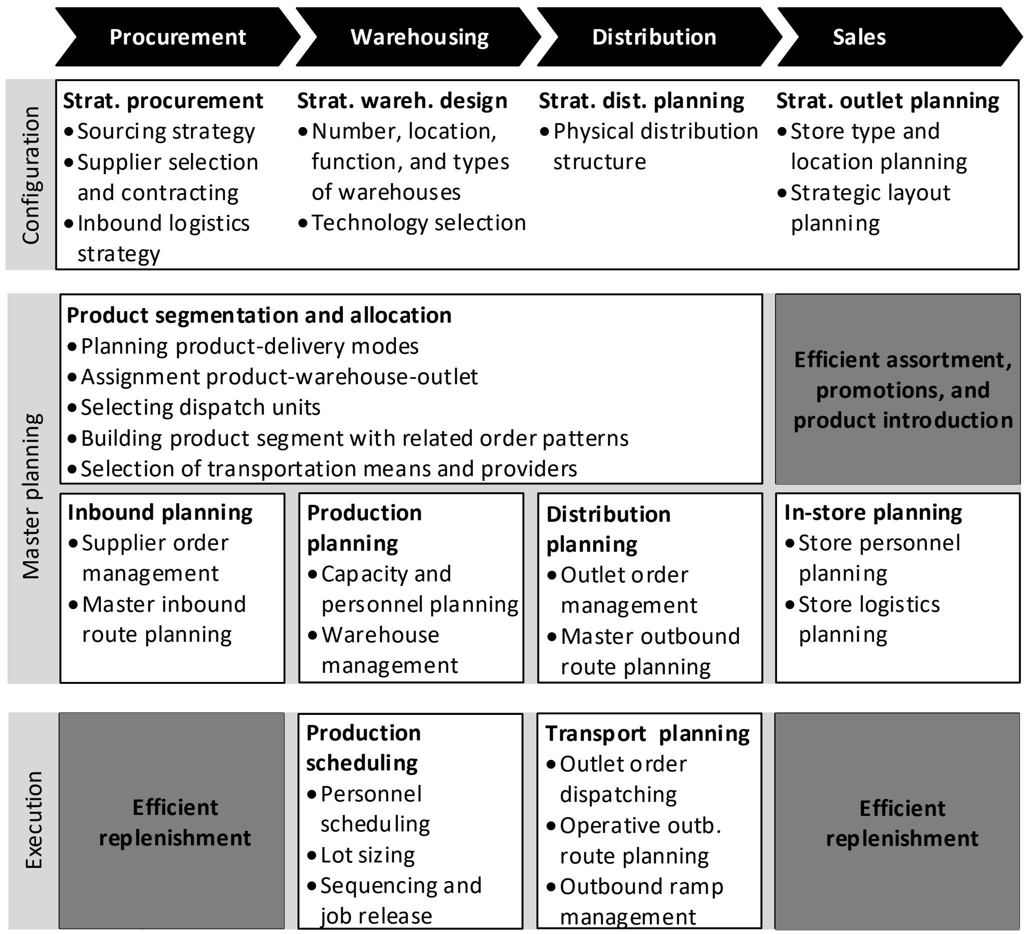

Figure 2.2: Comparison between the RDSCP and ECR (Hübner et al., 2013; Kotzab, 1999; Salmon, 1993)

The *efficient replenishment* strategy relates to the order planning and in-store fulfillment. The strategy is based on an increased use of information sharing and thereby connects to the studies about research question 1. This strategy serves as input to section 2.2.

The strategies, *efficient assortment*, *efficient promotions*, and *efficient product introductions* are all part of the master category planning. The *efficient product introductions* and *efficient promotions* are highly connected to the second research question of demand-stimulating activities (see Figure 1.3, page 4). These strategies serve as input in section 2.3.

2.2. Planning with Information Sharing

This section revolves around five subsections of how shared information can be utilized for planning. Firstly, an introduction and overview of planning and information sharing in academic literature. Secondly, the focus is placed on the replenishment decision in grocery retailing, and particularly automatic replenishment system, their underlying logic, and use of shared information. Thirdly, the use of automatic replenishment systems for perishables and why additional shared information is needed for these type of products. As outlined above the replenishment decision controls the timing of when and how much products the stores receive, and is thereby expected to directly support the objective of aligning supply and demand. A similar reasoning can be made for the fourth subsection which presents inventory allocation policies and why shared information can contribute to this decision for allocation of perishables. Lastly, a summary of contextual variables that have been reported to affect the value of sharing and using information.

2.2.1. An Overview

Information sharing is extensively studied in previous literature – not only for grocery retailing, but all types of industries and dates back to the identification of the Forrester (bull-whip) effect (Forrester, 1958; Lee et al., 1997) (for broad review of the literature see Giard and Sali (2013); Huang et al. (2003); Montoya-Torres and Ortiz-Vargas (2014); Sahin and Robinson (2002)). Some articulates information sharing as an embedded part of supply chain integration (Flynn et al., 2010; Frohlich and Westbrook, 2001) and others more generally as a mean to enhance supply chain coordination (Arshinder et al., 2008) and hence enhance supply chain performance (Baihaqi and Sohal, 2013; Barratt and Oke, 2007; Myrelid, 2015; Sezen, 2008).

A distinction between information sharing and information utilization is necessary as the same shared information may be utilized for different planning decisions. Information sharing refers to the *availability* of operational, tactical, or strategic insights (Kembro and Näslund, 2014), whereas information utilization refers *to the inclusion of received information, from the supply chain or surrounding environment, in the internal or collaborative decision processes (referenced from Paper #4)*. Thus, it is apparent that information sharing is a prerequisite for information utilization.

Table 2.1 (from Paper #1) illustrates a summary (non-industry specific) of studies that have been conducted – showing the type of information that has been considered and the corresponding planning and control decision of where the information was utilized. The numbers in the table refer to the number of papers, which has considered a particular combination of shared information and planning and control decision. The overview consists of 131 papers in total. Thus many papers have considered more than one type of information or one type of planning decision at once.

Table 2.1: Number of papers examine the relationship between information sharing and planning and control decisions (Choi, 2010; Huang and Zhang, 2013; Kumar and Pugazhendhi, 2012; Montoya-Torres and Ortiz-Vargas, 2014; Sahin and Robinson, 2002; Yang and Zhang, 2013)

	Planning and control decision									
Information shared	Facility Location	Outsourcing	Production & distribution planning	Capacity Allocation	Inventory Allocation	Safety Stock	Order Replenishment	Shipment	Not specified	Sum
Demand forecast	0	0	3	1	3	1	7	1	2	18
Production schedule	0	0	4	0	0	0	3	1	0	8
Forecasting model	0	0	0	0	1	0	0	0	0	1
Time fence	0	0	1	0	0	0	0	0	0	1
Inventory level	0	0	1	1	6	3	21	5	3	40
Backlog cost	0	0	0	0	0	0	1	0	0	1
Holding cost	0	0	0	0	0	0	3	0	0	3
Service level	0	0	0	0	1	0	0	0	1	2
Capacity	2	4	3	0	0	0	6	1	1	17
Manufacturing lead time	0	0	0	0	1	0	3	0	1	5
Cost of process	2	3	3	0	0	0	1	0	0	9
Quality	0	0	0	0	0	0	1	0	1	2
Delivery	0	0	1	0	0	0	3	3	1	8
Delivery lead time	0	0	0	0	0	0	2	0	0	2
Variation of lead time	0	0	1	0	0	0	1	1	3	6
Demand	0	1	4	2	2	0	41	3	11	64
Demand variability	0	0	0	1	0	0	6	0	3	10
Batch size	0	0	2	0	0	0	5	1	0	8
Demand correlation	0	0	0	0	0	0	3	0	0	3
Delivery due date	0	0	1	0	0	0	1	1	0	3
Not specified	0	0	1	0	2	0	6	0	8	17
Sum	4	8	25	5	16	4	114	17	35	228

As demonstrated with Table 2.1 several researchers have investigated the topic of information sharing, in particular how it can be used to support the replenishment decision with 114 papers, whereas the inventory allocation only has been investigated in 16 papers. Within these papers, it is common to estimate the value, or benefits, of utilizing a particular piece of information. Usually the value of shared information is quantified by use of analytical calculations in a dyadic supply chain (Aviv, 2001; Bourland et al., 1996; Cachon and Fisher, 2000; Cho and Lee, 2013; Gavirneni et al., 1999; Guo and Li, 2014; Jonsson and Mattsson, 2013; Lee et al., 2000; Raghunathan, 2001; Yu et al., 2001), while few studies have examined a supply chain with *N*-stages (Chen, 1998; Ganesh et al., 2014; Li et al., 2006; Sepulveda Rojas and Frein, 2008; Wu and Cheng, 2008). Nevertheless, the actual value, of using the information differs considerably among studies (Jonsson and Mattsson, 2013; Ketzenberg et al., 2007; Rached et al., 2015), and very little empirical evidence have been provided for information sharing in more than dyadic relations (Kembro and Näslund, 2014). The focus on dyadic relationships (one seller one buyer) also explains why the problem of inventory allocations has received little attention as this problem only exist if there are multiple buyers.

In addition, there is no systematic framework which explains what, when, how, or with whom information should be shared, and how it differs in various types supply chains (Jonsson et al., 2016; Jonsson and Mattsson, 2013; Kembro et al., 2014; Lau et al., 2002; Sahin and Robinson, 2002). Or, how the shared information should be linked to the receiving company for supply chain purposes (Jonsson and Myrelid, 2016; Kaipia, 2009; Kim and Narasimhan, 2002; Myrelid, 2015). In other words: "*despite the progress, the research underscored the fact that many SC managers do not fully understand the nature and role of an information-sharing capability. Thus, a proven, well-traveled path with well-defined signposts to the development of this important SC capability has not yet been established*" (Fawcett et al., 2009, p. 241). A conceptual framework provided by Kembro et al. (2014) is a valuable contribution towards establishing this well-traveled path. However, it is not easily identified from this how the information is incorporated in the decision processes, which is necessary to benefit from it (Baihaqi and Sohal, 2013; Moinzadeh, 2002; Zhou and Benton, 2007).

2.2.2. Automatic Replenishment

Information sharing plays an important role in grocery retailing especially for *efficient replenishment* also known as automatic replenishment system. This is mainly used for products with a stable, high demand volume, and generally with a long shelf life (Potter and Disney, 2010; Van Donselaar et al., 2010), but attempts to use it for perishables is also reported (Broekmeulen and van Donselaar, 2009; Lowalekar and Ravichandran, 2015; Tekin et al., 2001). From the ECR domain, automatic replenishment is known as the strategy *efficient replenishment* (Reyes and Bhutta, 2005; Yao and Dresner, 2008), and it represents nearly half of the projected savings from ECR (Salmon, 1993). Efficient replenishment consists of two phases. The driving force of phase 1 is to share POS-information and use as triggers for the next replenishment decision – both for the inbound and outbound replenishment process at the grocery retailer as illustrated in Figure 2.2 (Salmon, 1993). Phase 2 builds on the foundation from phase 1 and aims to integrate the two independent replenishment processes into one (Salmon, 1993), which is also known as multi-echelon inventory systems (see e.g. Clark and Scarf (1960)).

Besides efficient replenishment, a number of sophisticated supply chain initiatives has been developed during the last decades to increase interfirm coordination of the replenishment as illustrated in Figure 2.3 (Arshinder et al., 2008; Yao and Dresner, 2008). The common characteristic is an increased use of shared information, and they can be found under the umbrella term automatic replenishment programs, automatic replenishment systems, or automatic store ordering (Ellinger et al., 1999; Sabath et al., 2001; Thomassen, 2013; Van Donselaar et al., 2010; Yao and Dresner, 2008). Figure 2.3 outlines some of the main methods found in the literature.

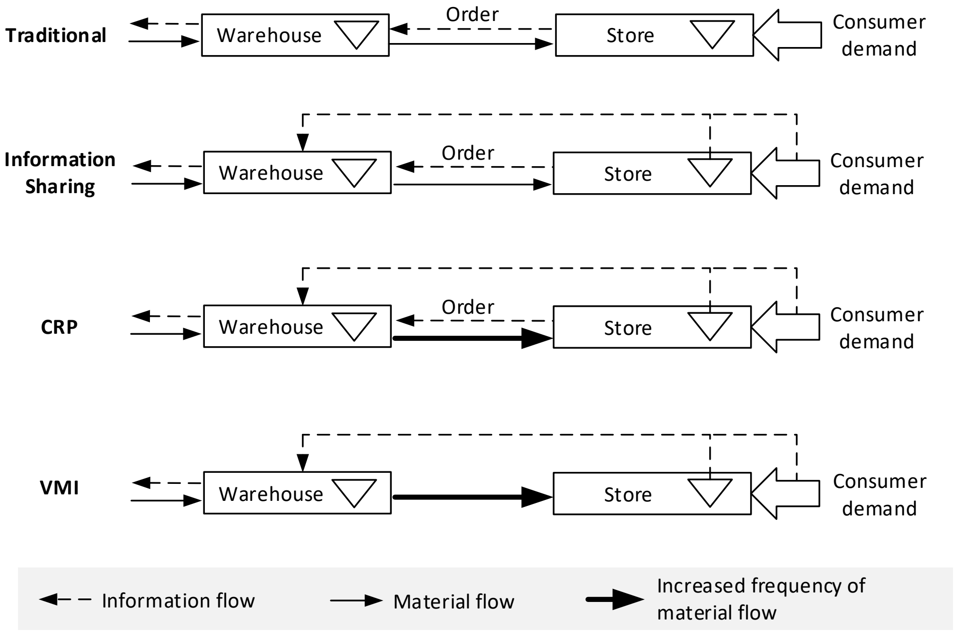

Figure 2.3: Illustration of automatic replenishment programs (Yao and Dresner (2008))

First, in Figure 2.3 traditional ordering is when the store places an order at the warehouse and the warehouse plans and delivers according to that order. Second, information sharing alone allows the warehouse to observe the actual consumer demand and maybe also inventory levels at the store. However, the actual ordering and delivery process is unaffected (Yao and Dresner, 2008). Based on a survey, Stank et al. (1999) found that information sharing can lead to improved logistical performance for food supply chains. However, afterward it has been shown that it is necessary to implement certain supply chain initiatives to benefit from information sharing (Barratt and Oke, 2007; Kaipia et al., 2013; Zhou and Benton, 2007). Third, the continuous replenishment program (CRP) is an example of such initiative and the first step to move beyond only sharing information (Raghunathan and Yeh, 2001). Specifically, CRP implements a continuous replenishment process where the replenishment is triggered by the actual sales and not an order (Sabath et al., 2001), which also often increases the delivery frequency (Yao and Dresner, 2008). This corresponds to the first phase of efficient replenishment strategy. Fourth, vendor managed inventory (VMI) includes the same features as CRP (Daugherty et al., 1999; Yao and Dresner, 2008), but now the vendor/supplier/warehouse has the responsibility for the replenishment and decides what and when to deliver (Daugherty et al., 1999; Sabath et al., 2001; Yao and Dresner, 2008).

A setup similar to the CRP is commonly found in grocery retailing, meaning that the stores have to finally approve the suggested order quantity (Van Donselaar et al., 2010). The underlying policy in these automatic replenishment systems is based on an (R,s,nQ) inventory policy to determine the timing and quantity for each order (Potter and Disney, 2010; Van Donselaar et al., 2010). I.e. every R period the inventory level is observed; if it falls below, s, the re-order point n number of batches with the size Q is ordered (Potter and Disney, 2010).

The benefits of increasing information sharing, e.g. through automatic replenishment systems, have mainly been evaluated by traditional supply chains oriented measures such as ordering costs, inventory levels, on-time deliveries, bullwhip etc. (see e.g. (Daugherty et al., 1999; Potter and Disney, 2010; Stank et al., 1999; Yao and Dresner, 2008). However, it has been suggested that this kind of improved transparency also could improve food waste in the food supply chain (Kaipia et al., 2013; Mena et al., 2014) but it remains a gap in the current literature.

2.2.3. Automatic Replenishment for Perishables

With perishable products currently accounting for 35% of the growth in the grocery market (Nielsen, 2016b) grocery retailers have gained an increased curiosity towards these products and also how to automate the replenishment process (Broekmeulen and van Donselaar, 2009). For perishables that are packed individually, i.e. those that are not sold in bulk and by weight, it should be possible to apply the same system as for products with a long shelf life. However, directly applying an automatic replenishment system with an (R,s,nQ) inventory policy has been found to be inadequate as some products might expire during the replenishment cycle (Van Donselaar et al., 2006). Consequently, the perishable inventory management literature (originating from the blood industry) has been used to establish more advanced policies for these products with short shelf life. Comprehensive review papers have continuously been published on this topic, and the reader is referred to these papers for a more thorough presentation (Bakker et al., 2012; Goyal and Giri, 2001; Janssen et al., 2016; Nahmias, 1982; Raafat, 1991). From this body of knowledge, it has been shown that the inventory performance can be improved by including not only the amount on inventory but also the age distribution of the inventory (referred to as remaining shelf life information (e.g. Nahmias (1982)). Naturally, it has been proposed to adopt this to automatic replenishment systems for perishables (Van Donselaar et al., 2006).

The perishables inventory management literature can be categorized into four overall groups (see Figure 2.4) depending on how the shelf life and demand is modeled (Janssen et al., 2016). Random shelf life means that the exact expiration date is unknown (e.g. fruit), whereas the expiration date is known and predetermined with a fixed shelf life (e.g. dairy products). Demand is modeled either as being deterministic with fixed values or stochastic where uncertainty is included. Consequently, random shelf life and stochastic demand would be the most difficult situation to handle.

Shelf life		
	Random shelf life Deterministic demand	Random shelf life Stochastic demand
	Fixed shelf life Deterministic demand	Fixed shelf life Stochastic demand
	Demand	

Figure 2.4: Broad classification of perishable inventory management (Janssen et al., 2016).

In this thesis, attention is made exclusively for the fixed shelf life and stochastic demand. Stochastic demand is selected as this is closer to reality, and the findings related to products with a fixed shelf can later be extended to include products with a random shelf life, by using estimates for the remaining shelf life, e.g. based on time and temperature tracking (Ketzenberg et al., 2015). For products with a fixed shelf life, the EWA policy presented by Broekmeulen and van

Donselaar (2009) is particularly interesting for grocery retailing because it is developed with the specific purpose of extending automatic replenishment systems to perishables. The EWA policy assumes fixed shelf life, stochastic demand, and is intuitive to use. However, it also assumes that the automatic replenishment system has access to remaining shelf life information from the stores, i.e. stores should then capture and share this information to make such calculations possible. In simple words, it functions by adjusting the ordering quantity according to the expected amount of products outdating during the replenishment cycle. Mathematically, the EWA policy can be expressed as follows:

$$if\ I_t - \sum_{i=t+1}^{t+R+L-1} \hat{O}_i < \sum_{i=t+1}^{t+R+L} E[D] + SS \quad \text{then:}$$

$$Q_t = \left\lceil \frac{\sum_{i=t+1}^{t+R+L-1} \hat{O}_i + \sum_{i=t+1}^{t+R+Lt} E[D] + SS - I_t}{B} \right\rceil \qquad (1)$$

Where:

I_t: inventory position (inventory on hand plus inventory in transit) at time t.
R: review period (number of days until next review)
L: lead time (from the order is placed to the order is received)
$E[D]$: expected demand
SS: safety stock, fixed
B: batch size (order multiplier between the store and the warehouse)
Q_t: order quantity (number of batches) ordered at time t
$\hat{O}_i$: estimated amount of products outdating

To estimate the amount of products outdating, Ô, the expected demand for each day is subtracted from either the oldest (in case of first-in-first-out (FIFO) depletion), or the newest products (in case of last-in-first-out (LIFO) depletion) on hand. Then, any products remaining, with expiration on that day, will be the estimated amount of products outdating. This procedure is then continued for L+R-1 number of days. For mathematical notation the of this the reader is referred to Broekmeulen and van Donselaar (2009).

Some modifications to the EWA policy have also been proposed. Specifically, Duan and Liao (2013) propose an old inventory ratio (OIR) policy where, compared to the EWA policy, if the ratio of old products (this is determined subjectively) compared to the overall inventory level is above a given threshold (δ) a new replenishment order is triggered. E.g., if the old inventory consists of products with a shelf life less than five days, and in this example, a total volume of 20 products compared to the total inventory level of 50 products will give a ratio of (20/50) 0.4. This ratio is then compared to the threshold value, δ, which is optimized through simulation.

Another approach is to use a continuous review policy instead of a periodic review policy. It is well-known that a continuous review policy requires less safety stock than a periodic review system because the periodic system has to buffer against uncertainty both during the replenishment lead time and the review period (Silver et al., 1998). In this domain, the (Q,r,T) continues review policy is found (Tekin et al., 2001). Here, an order *Q* is placed either if the inventory level drops below *r* or if no order has been placed during the last *T* time units (e.g. *T* numbers of days).

A comparison between a traditional order-up-to policy (periodic), traditional re-order point policy (continuous), EWA, OIR, and an updated version of the (Q,r,T) policy has been made through a simulation study (Lowalekar and Ravichandran, 2015). The updated (Q,r,T) policy delivers the best results, while the EWA and OIR share the second place. However, due to the convenience (in regards to transportation and restocking shelves), periodic review systems are the primary inventory policies applied in grocery retailing (Van Donselaar et al., 2006), which questions the applicability of (Q,r,T) policy. Additionally, the use of the subjective threshold value, δ, in the OIR policy favorites the EWA policy for automating the replenishment of perishables in grocery retailing.

Some gaps appear in the literature concerning the estimation of the actual value of applying the EWA policy. When originally introduced (Broekmeulen and van Donselaar, 2009) it was only evaluated in a dyadic relation, based on artificial data (the same procedure was followed by Lowalekar and Ravichandran (2015)), and only with a strictly FIFO or LIFO depletion. This is of concern, as it has been noted that dyadic relations are too simplistic and do not fully reflect reality (Huang et al., 2003), and shelf depletion for perishable products is not either FIFO of LIFO but somewhere in between (Janssen et al., 2016). On a more technical note, the EWA policy applies fixed safety stock, and this may result in a too high order quantities (and subsequent inventory levels) if demand is non-stationary (Van Donselaar and Broekmeulen, 2012). Through somewhat cumbersome estimations (this includes regression of seven independent variables) a method for setting these safety stock levels has been proposed (Minner and Transchel, 2010; Van Donselaar and Broekmeulen, 2012). However, for the more pragmatic grocery retailer, no good solution appears so far to have been found and is open for further research.

2.2.4. Inventory Allocation for Perishables

Inventory allocation concerns the issue of how products are assigned to stores from a common warehouse. However, it is often neglected and is an understudied planning decision (see Table 2.1, page 12) for perishables (Karaesmen et al., 2011) even though the decision frequently occurs in grocery retailing. As indicated in Paper #1, previous studies on information sharing have mainly concerned dyadic relations even though it may not fully represent reality (Huang et al., 2003). Inventory allocations exemplify why studying *only* dyadic relations is not enough (as this problem do not exist in dyadic relations), and as a result, only limited attention has been made to this area.

Inventory allocation is needed in case of shortage at the warehouse, which is then known as rationing policies (Diks and De Kok, 1998; Van der Heijden, 1997). However, for perishables, the problem is further complicated as the warehouse may hold the same products with various levels of remaining freshness. Thus, even though the warehouse holds a sufficient amount of products on inventory, the freshness of the products should still be allocated to the stores. Moreover, in some cases, the problem will extend to assigning both the right volume and the right level of freshness (here referred to as volume allocation and age allocation) (Federgruen et al., 1986; Prastacos, 1978). In either case, it would seem intuitive that if the warehouse knew the remaining shelf life at the stores, they would be able to make better inventory allocation decisions. Consequently, the use of shared information (sharing remaining shelf life information – just like the replenishment decisions) becomes a central element to this discussion.

For volume allocation (in case of shortage) three common allocation policies for non-perishable products are (1) fair share allocation, (2) consistent appropriate share allocation, and (3) priority allocation (De Kok et al., 1994; Van der Heijden et al., 1997). With the *fair share allocation* the available inventory is distributed across requesting stores to obtain an equal probability of a stock out. Whereas, the *consistent appropriate share* allocates the available inventory based on the safety stock levels at downstream locations – the higher safety stock, the more allocated products as uncertainty is higher these locations (Van der Heijden, 1997). To avoid negative allocations (transshipments) the balanced stock assumption is necessary for these two policies, meaning that the individual inventory levels (at the downstream locations) do not deviate significantly from the average inventory level (Van Donselaar, 1990). Lastly, with priority allocation, each downstream location has a predefined priority, and the available inventory is allocated accordingly.

For allocation of perishables it has been noted that: "*the age of goods supplied/allocated downstream may be as important as the amount supplied*" (Karaesmen et al., 2011, p. 411). The studies have been greatly simplified to reduced complexity in the problem, e.g. Fujiwara et al. (1997) assume that the products start to age at the stores and not at the warehouse. This makes the problem similar to non-perishables as the warehouse does hold the same product with various levels of freshness. Nevertheless, a general finding is that to minimize shortage (volume allocation) products should be allocated following the fair share allocation rule. To minimize the risk of outdating (age allocation) products with a short remaining shelf life should be distributed evenly (relative to demand) across all stores (Lystad et al., 2006; Prastacos, 1978).

Obviously, there is a need to produce research on this topic without making these types of simplifying assumptions (Karaesmen et al., 2011). However, the main concern within this body of literature is a somehow rather distant reflection of reality. If a warehouse has a product with two different ages, it is not convenient for the pick-and-pack process to allocate products from both age categories to all requesting stores. The pick-and-pack process would be more likely to empty the oldest category first and then move on to the next – this would also make traceability concerns easier to handle. Similar, even if the old products were to be distributed evenly across the requesting stores it is highly unlikely that each store can get the exact same amount of product – thus which store should receive more and which should receive less of the old products? Another concern is that the allocation policies presented above mainly focuses on how to distribute the products that are close to expiring. However, if a store only receives products twice a week, it might be important this delivery frequency somehow is reflected in the inventory allocation to ensure the products stay fresh during the entire replenishment cycle.

2.2.5. Contextual Variables and Information Sharing

For information sharing to be effective managers and decision makers must incorporate the increased information into their decision processes (as e.g. the replenishment or inventory allocation decision as discussed above) (Baihaqi and Sohal, 2013; Moinzadeh, 2002; Zhou and Benton, 2007). However, even if it is incorporated the literature does not fully agree on the benefits obtained from it – also known as the value of information (Jonsson and Mattsson, 2013; Ketzenberg et al., 2007; Rached et al., 2015). A plausible explanation for these different results is that contextual variables moderate the result (Danese, 2011; Jonsson and Mattsson, 2013; Kembro, 2012). I.e. there is no "one-size-fits-all", and there is no single best way for information sharing to be effective, and the benefits will depend on specific contextual variables (Kembro, 2012). With this in mind, this section outlines some of the most common contextual variables discussed in the literature concerning the value of information sharing. Table 2.2 provides a short summary.

Lee et al. (2000) observed that the value of information increases as demand uncertainty increases while Chen (1998) found the opposite conclusion. However, this might be due to how the experiment was conducted as Gavirneni et al. (1999) found that the value is highest for moderate values of demand uncertainty in capacitated supply chains. Ketzenberg et al. (2007, p. 1235) also stress these conflicting results by presenting six papers arguing that the value increases as uncertainty increases; four arguing the value decreases as uncertainty increases, and lastly two that find that moderate values give the highest value. Besides that the value of information is dependent on the demand uncertainty, Gavirneni et al. (1999) and Jonsson and Mattsson (2013) also finds that is it dependent on the demand type (trend, seasonal, etc.) and different type of information is more valuable with different demand types.

Several researchers report similar findings regarding the relationship between the value of information and order quantity. Moinzadeh (2002) found the highest value when the order quantity had moderate values, and similarly, it was observed that the difference between the re-order point and the order-up-to level (which effectively becomes the order quantity) should not be too extreme (Gavirneni et al., 1999). Additionally, it has been found highly beneficial to reduce the batch sizes (Cachon and Fisher, 2000).

The length of the supply chain may be understood as a combination of the number of echelons and the lead time between them, i.e. ten days lead time between two echelons might be considered longer than a five echelon supply chain with one day lead time between each echelon. If so, a general finding suggests that the value of information is higher for longer supply chains than shorter supply chains (Chen, 1998; Ganesh et al., 2014; Jonsson and Mattsson, 2013; Lee et al., 2000; Moinzadeh, 2002). Few studies indicate that it might not only be the length of the supply chain but also depending on the structure itself (Li et al., 2006; Sepulveda Rojas and Frein, 2008).

Considering the possibility of product substitution (e.g. the same product in multiple colors or packaging sizes) it was shown that the value of information decreases as the level of substitution increases, especially further upstream in the supply chain (Ganesh et al., 2014).

As a small note, Kembro (2012) proposes that the shelf life of a product may moderate the value of information sharing. However, no explanation is provided as to why this could be apparent or if products with short or long shelf life would benefit the most from information sharing. This is particularly interesting in the context of perishables as these are characterized by their shelf life (Van Donselaar et al., 2006).

Table 2.2: Summary of moderating contextual variables

Contextual variable	**The value of information is highest when:**
Demand uncertainty	No unambiguous finding appears to has been reached.
Order quantity	The order quantity is moderate in size.
Length of supply chain	The supply chain (number of echelons and lead time) is long.
Substitution	Substitution is low.
Shelf life	No findings appear to have been reached.

2.3. Planning Demand-Stimulating Activities

From a supply chain perspective, demand-stimulating activities create additional difficulties as demand becomes more unpredictable, increases the need for capacities in both transportation, warehouse(s), and at suppliers, and cannibalizing sales from other products. This difficulty is also frequently demonstrated with an increased bull-whip effect due to price fluctuations (Huchzermeier and Iyer, 2010; Lee et al., 1997). On the other hand, these activities are effective for getting consumers attention and hopefully leading to increased sales and market share (Ettouzani et al., 2012; Salmon, 1993). Currently, promotional sales is an important part of the revenue for retailers, and as illustrated in Figure 2.5 it accounted for 25% of the total sales in Great Britain in 2004. In 2016 it was measured to 29% in Great Britain – which was considered as a major drop as it has been rather stable for some years around 34% (Nielsen, 2016a). However, being 25%, 34%, or somewhere in between it is still a significant part of the total sales volume and adequate management of this is needed (Ettouzani et al., 2012; Martec, 2017).

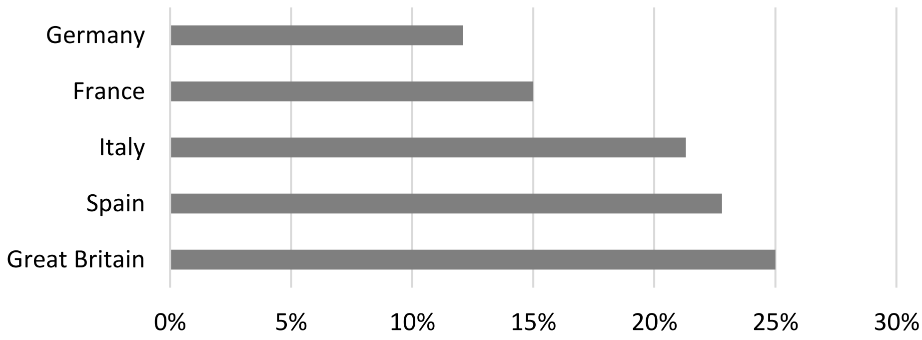

Figure 2.5: Percentage of sales (in €) made on promotions. January - June 2004 (Gedenk et al., 2010)

As presented in Section 2.1, planning for these types activities falls within the tactical or mid-term planning horizon in grocery retailing (Hübner et al., 2013). A research area, which previously only was implicitly considered through concepts like ECR, but has recently started to receive explicit attention in the academic literature (see e.g. Ettouzani et al. (2012); Hübner et al. (2013); Kuhn and Sternbeck (2013); van Donselaar et al. (2016); Yurt et al. (2010)). Consequently, this section is divided into two: first a brief presentation of the strategies from ECR and possible limitations, and secondly, a short introduction to sales and operations planning and arguments why this tactical planning approach from manufacturing could be a potential remedy grocery retailing.

2.3.1. Strategies from Efficient Consumer Response

The two strategies, *efficient promotions* and *efficient product introductions*, falls directly under the umbrella of managing demand-stimulating activities. The strategy *efficient store assortment* aims to "*optimize the productivities of inventories and store space at the consumer interface*" (Salmon, 1993, p. 4), and is not considered uniquely for demand-stimulating activities but for more general assortment decisions (Pearce, 1996).

At the time of the inception *efficient promotions* was formulated to reduce the inefficiency and sometimes unsynchronized use of trade promotions (supplier – grocery retailer) and consumer promotions (grocery retailer – consumer) (Salmon, 1993). In other words, reducing forward buying (when retailers buy more than needed for a promotion) by rewarding retailers based on how many products they sold to consumers rather than a quantity discount (Reyes and Bhutta, 2005). Practically, achieved by joint promotion planning between the suppliers and grocery retailer (Pearce, 1996). Similar, instead of disconnected product development processes *efficient product introductions* aimed to bring suppliers and grocery retailers together and to maximize the effectiveness of new product development and introduction activities (Reyes and Bhutta, 2005; Salmon, 1993).

Collectively, ECR encourages collaboration across the supply chain. ECR provides a good vision, but to provide a structure and put a process in place CPFR emerged as an evolution from the ECR strategies (Barratt and Oliveira, 2001; Seifert, 2003). Not only to manage demand-stimulating activities but to increase collaboration in the supply chain (Barratt and Oliveira, 2001). It consists of a nine-step process as illustrated in Figure 2.6, where especially step 4 and 5 is target towards the demand-stimulating activities (Danese, 2006; Seifert, 2003). In contrast to traditional planning, forecasting, and replenishment where each partner establish its own set of plans, CPFR aims to establish a common plan across the supply chain (Seifert, 2003)

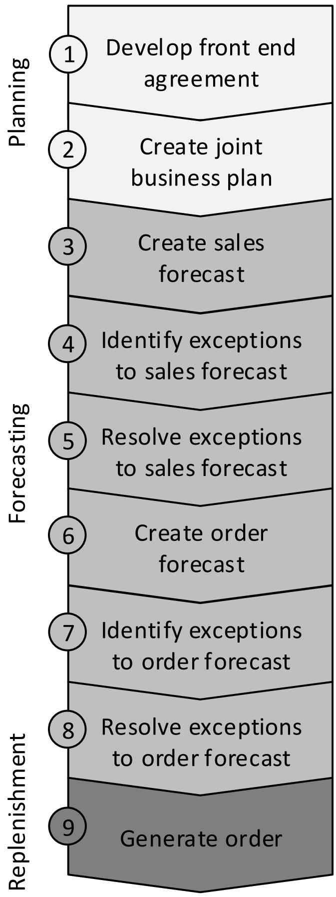

Figure 2.6: Nine-step CPFR process (Danese, 2006)

Both ECR and CPFR has been known practices for 20 years, but grocery retailers are still struggling with how to manage their demand-stimulated activities today (Alftan et al., 2015; Ettouzani et al., 2012; Martec, 2017; Småros, 2017), which is also visible with stock-out 11% of the time (Ettouzani et al., 2012). Firstly, ECR and CPFR are generally demand-driven, i.e. promote products, generate the best possible forecast, and ensure products are pushed towards the consumers. One could argue that this approach presumes that supply always is available – but that is not necessarily the case in food supply chains which is characterized by long and uncertain supply (Fredriksson and Liljestrand, 2015; Romsdal, 2014). Thus, a more balanced approach might be desirable. Secondly, ECR proposed separate strategies for managing promotions, product introductions, and seasonal changes in assortment – these are all demand-stimulating activities, which often take place at the same time, e.g. new products that are introduced at a special price for Christmas. Thus, there is a need to coordinate these types of decisions into a unified process.

2.3.2. Sales and Operations Planning

The general objective of sales and operations planning (S&OP) is to balance supply and demand, in the medium term, by providing an instrument for vertical (business strategy) alignment and horizontal alignment across the supply chain (Tuomikangas and Kaipia, 2014; Wagner et al., 2014). To use S&OP for demand-stimulating activities focused is, at first, placed on how to achieve the horizontal alignment. Consequently, the following definition is adopted for this thesis: "*the aim of sales and operations planning (S&OP) is simply to maintain a balance supply and demand*" (Jacobs et al., 2011, p. 90; Yurt et al., 2010, p. 121). The underlying idea is to plan for activities with takes several weeks of preparation, e.g. extra recruitment, building up seasonal inventory, or allocate products between facilities (Jacobs et al., 2011; Thomé et al., 2012).

The process is usually held monthly and is cross-functional involving employees from sales, operations, finance, supply chains, and top management (Jacobs et al., 2011; Thomé et al., 2012; Wagner et al., 2014). The general activities in the five-step process are depicted in Figure 2.7. The outcome of the process is an agreed set of numbers – traditionally on a product family level, even though it has been reported that some industries perform it on a SKU level (Ivert et al., 2015; Thomé et al., 2012).

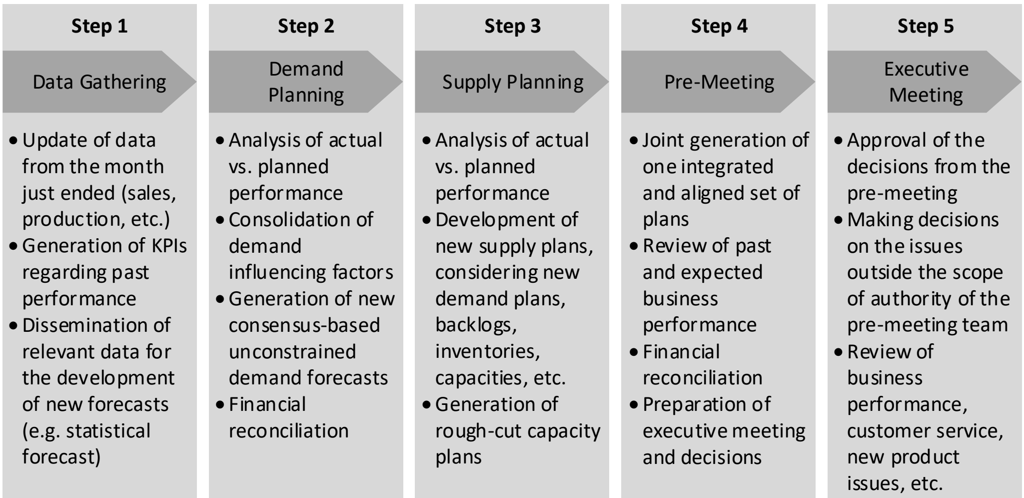

Figure 2.7: Five-step S&OP process (Wagner et al., 2014)

With an aim of obtaining a *balance* between supply and demand S&OP creates a slightly other foundation for planning than the demand-driven concepts as e.g. ECR or CPFR. Additionally, with its cross-functional nature it involves employees from all departments and ensures a vivid representation of reality and not just viewpoints from a single function. The following subsections briefly present some of the reported benefits of applying the S&OP process and afterward how S&OP has been analyzed and adapted for food supply chains.

Benefits of Sales and Operations Planning

Oliva and Watson (2011) report through a detailed case study how an electronic company redesigned its S&OP process to now include three separate forecasts (one statistical, one bottom-up from the planning department, and one top-down from sales directors). Important aspects of the forecast were product introductions, promotions, marketing strategies, price plans, and end-of-life plans. The main point for discussion during the S&OP meeting was to establish a consensus-based forecast and then validate the operational and financial consequences. After implementation, the inventory turnover and on-time delivery performance doubled, where the underlying mechanism was reported to be a significantly higher forecast accuracy and a more integrated organization with one set of numbers. Similarly, increased forecast accuracy (around 50%), reduced inventory levels (30%), and reduced order lead time (67%) were also reported by Goh and Eldridge (2015). S&OP is also found beneficial to cope with market uncertainty (Olhager and Selldin, 2007; Oliva and Watson, 2011).

Reaching the benefits of S&OP is not a guarantee (Wagner et al., 2014). It is indicated that to fully benefit from S&OP it is important to have a proper S&OP organization, a structure for meetings and collaboration, use of relevant performance measurements, and use of information technology (Grimson and Pyke, 2007; Thomé et al., 2014). Consequently, to analyze and ensure these benefits are reached, there is a call to study S&OP subject to the industry type (Thomé et al., 2014).

Sales and Operations Planning in Food Supply Chains

Two studies have been reported about S&OP for food supply chains – not explicitly for grocery retailers, but for food producers (Ivert et al., 2015; Yurt et al., 2010). However, these are still considered relevant as they shield some light on the difficulties when operating in this type of industry.

The first study reports that the S&OP-similar process was conducted weekly to monthly covering a horizon of 4-15 months and with a low maturity level (see e.g. Grimson and Pyke (2007) for a complete maturity model) (Ivert et al., 2015). The frequency of product introduction, the characteristics of demand and supply uncertainty, perishability, and high requirements to service levels requires the S&OP process to be adapted for this environment (Ivert et al., 2015). Interestingly, only a few of the involved companies in the study considered material supply as an input for the S&OP process, the outcome of "one-set of numbers" was hardly reached by any of them (Ivert et al., 2015).

Fluctuation in demand, instability in supply, seasonality, a large number of SKUs, and perishability is also echoed by Yurt et al. (2010) as characteristics that need to be taken into account for successful S&OP for food producers. As a result, the planning horizon in the food industry is often shorter, and the large number of SKUs necessitates the importance of finding the right level of aggregation for decision-making. Finally, supply determines what is going to be sold (Yurt et al., 2010, p. 136) – and to emphasize the importance of this an adapted S&OP process for the food supply chain with an initial supply planning (step 2) has been proposed as illustrated in Figure 2.8.

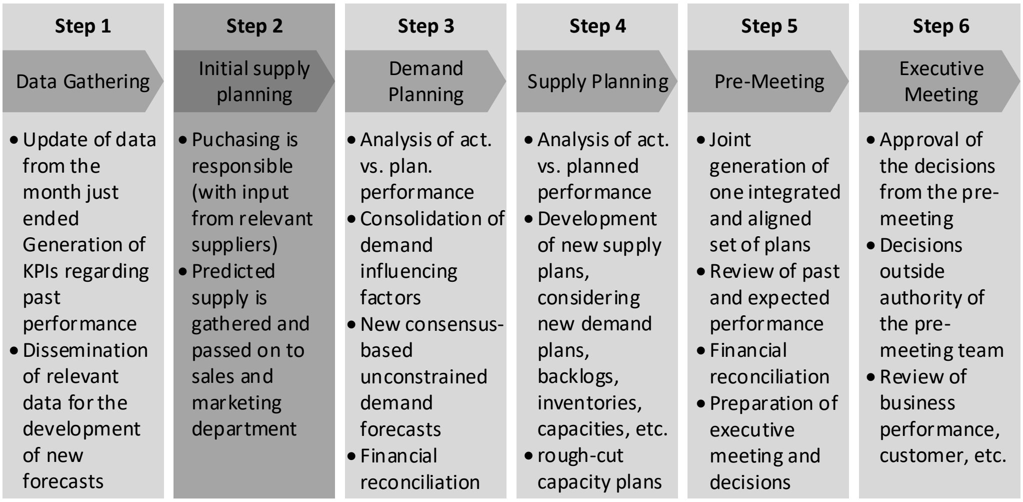

Figure 2.8: Six-step S&OP process for food supply chains (Yurt et al., 2010)

Even though a few studies have been conducted on S&OP in the food supply chain, it remains a gap if and how S&OP could benefit grocery retailers. Due to the mid-term planning horizon, its cross-functional nature and integration of plans across functions and supply chain members it appears as a valuable remedy for grocery retailers to manage their demand-stimulating activities.

2.5. Evaluating Performance in Grocery Retailing

None of the research questions aim to contribute or investigate the performance measurement literature of grocery retailing. However, to adequately discuss and evaluate the implications of the research findings it is necessary to identify essential performance measures for grocery retailing. Based on the literature and the interaction with grocery retailers throughout the PhD study this section outlines these identified measures.

Several comprehensive performance measurement systems has been proposed for food supply chains encompassing various levels (supply chain, organization, process) and dimensions (e.g. availability, quality, cost) (Aramyan et al., 2007; Bigliardi and Bottani, 2010; Bloemhof et al., 2013; Bourlakis, Maglaras, Aktas, et al., 2014; Van Der Vorst, 2006). These comprehensive systems include each nearly 20 performance measures, and even though it contributes to a more vivid evaluation, it also complicates assessments considerably. This is not an argument for stopping or decreasing reporting initiatives as each measure might serve different purposes.

The “moment of truth” for grocery retailers is when the consumers enter the stores and reach for the products on the shelves (Hübner et al., 2013). This explains why availability is one of the foremost important measures for grocery retailers (Aastrup and Kotzab, 2010; Corsten and Gruen, 2004; Gruen et al., 2002; Moussaoui et al., 2016). Additionally, for products with a short shelf life, consumers want a long remaining shelf life to pick them, i.e. the products need to be fresh (Göbel et al., 2015). A long remaining shelf life at the store also acts as a proxy for product quality (Van Der Vorst, 2006). Long remaining shelf life also gives stores more time to sell the products or more time for the consumer to use them before they expire, which contributes to fewer products being wasted (Kaipia et al., 2013; Van der Vorst et al., 1998). Not surprisingly, food waste is frequently cited as the most important measure for sustainable food supply chains as it shows too many products were available, it does not create any economic value, and has wasted natural resources up through the supply chain. (Bourlakis, Maglaras, Gallear, et al., 2014; Gerbens-Leenes et al., 2003; Kummu et al., 2012; Maloni and Brown, 2006). Lastly, storage and distribution are two significant measures in grocery retailing (Bloemhof et al., 2013; Bourlakis, Maglaras, Aktas, et al., 2014). They are not only financially expensive, but they also increase pollution and the energy consumption (Bloemhof et al., 2013; Fernie and Sparks, 2009). Table 2.3 summarizes the above brief discussion of the identified performance measures with a short explanation.

Table 2.3: Identified performance measures for grocery retailing

Indicator	Explanation
Availability	The fraction of demand that is fulfilled (without backorders)
Waste	The fraction of products being wasted compared to received
Remaining shelf life	Days until the product expire (freshness)
Storage	Inventory level and the cost of holding it
Distribution	Distance traveled per delivery and number of deliveries

2.7. Research Framework

The purpose of the section is to provide an encapsulating presentation of the theoretical foundation presented in this chapter, how it relates to the research objective and the two research questions.

The objective of this PhD research is to contribute to how grocery retailers can align supply and demand through improved decision making in their planning processes. With the two research questions, this was separated into the decision making for stable and stimulated demand. The middle part of Figure 2.9 shows the specific planning processes discussed within each of these areas and the corresponding literature that was found adequate for each question (left side of the figure). The right part of Figure 2.9 shows how the alignment of supply and demand (through replenishment, allocation, adequate product introductions, etc.) is expected to positively affect performance. Contextual variables may moderate the design of the S&OP process, as well as how shared information can be utilized at the receiving company, or moderate the impact on performance.

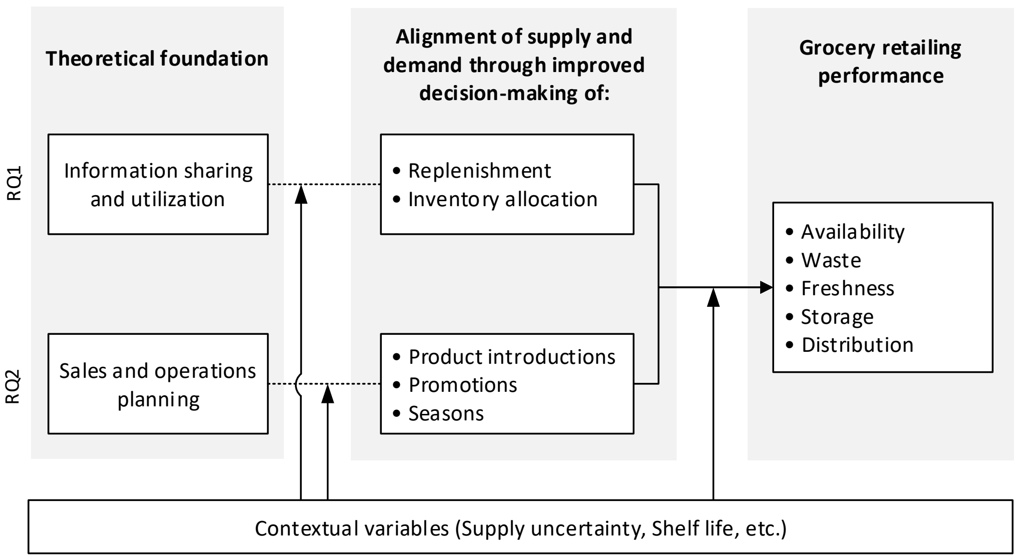

Figure 2.9: Research Framework

From Figure 2.9 it can also be observed that the upper part of the figure relates to Research Question 1 about information sharing, while the lower part relates to Research Question 2 about stimulated demand activities.

Research Design 3

This PhD study was an integral part of a four-year Norwegian research project named Retail Supply Chain 2020, which enriched the access to empirical cases as well as providing a forum for discussion and verification of findings. A major partner in the research project was one of the largest grocery retailers in Norway and has also been the main case throughout this PhD study. The PhD study consists of seven smaller sub-studies and the involvement with the grocery retailer was used in the initial phase to guide the research to ensure that the selected sub-studies had not only a theoretical relevance but also a practical interest.

The access to the Retail Supply Chain 2020 project reduced one of the most frequent concerns when conducting empirical research – the concern of "getting access" (Croom, 2009; Gummesson, 2000). On the other hand, to ensure that the case selection in the studies was not biased, some of the studies were supplemented with either additional cases of other grocery retailers or inclusion of the downstream supply chain when needed.

Table 3.1 summaries how each research question was further specified into the seven sub-studies, which all have one corresponding paper where the results have been reported. The table also shows how empirical data that was collected and the main outcome (Figure 3.1, on page 32 provides a more detailed picture of the collected data).

Table 3.1: Methods and data for addressing each research question

Research question	Method	Data collection	Main outcome	Paper
1a: How is information sharing characterized in grocery retailing?	Literature study		Identified gaps in literature	#1
	Literature study and case example	Questionnaire, workshop	Enhanced information utilization concept with information facets and mapping tool	#2
1b: What is the impact of information sharing in grocery retailing?	Multiple case study	Data records, workshop, interviews, observations	Evaluated the potential improvement on food waste metrics	#3
	Simulation	Data records, interviews	New replenishment policy and evaluation of its impact on alignment of supply and demand	#4
	Analytical Mathematical		Guidelines for improving inventory allocations based on information sharing	#5
2: How do grocery retailers effectively align supply and stimulated demand?	Single case study	Interviews	Understanding of tactical planning in grocery retailing	#6
	Multiple case study	Interviews	A set of propositions for managing stimulated demand	#7

The research design argues how and why a research problem has been examined in a particular manner and may be interpreted to consist of (1) data selection, (2) data collection, and (3) data analysis (Kothari, 2004; Voss et al., 2002; Yin, 2013). As this PhD study was part of the Retail Supply Chain 2020 project *where* to collect data (data selection) was clarified, whereas *what* to collect and *how* to collect and analyze it was the primary task when designing the research. The next section elaborates on these aspects followed by a section that presents how the research quality was ensured throughout the studies.

3.1. Research Methods

A research method refers to the technique of data collection and data analysis (Croom, 2009), i.e. *how* and *what* data that is collected as well as how it is examined. A critical issue when designing research is to choose the most appropriate research method for the question under investigation (Croom, 2009; Handfield and Melnyk, 1998). Thus, in the following an elaboration of each research question and accompanying research method is presented. The reader may use Table 3.1 and Figure 3.1 (at the end of the section) in parallel with reading to alternately switch between details and overview.

3.1.1. Research Question 1

How does information sharing contribute to align supply and demand in grocery retailing?

It is expected that by synthesizing the answers from the two subquestions (1a and 1b) Research Question 1 can be answered. Consequently, no independent study was specifically designed for Research Question 1 but for the subquestions instead.

RQ 1a: How is information sharing characterized in grocery retailing?

The journey of this PhD study started with a single curiosity similar to how Research Question 1 is formulated – but expanded into the research of stimulated demand as well to provide a more holistic representation of reality. However, because this was the point of departure a preliminary literature study was initiated to familiarize with the body of knowledge and identify potential gaps in the literature. It was quickly noticed that several review papers about information sharing in supply chain management literature had been published within a timeframe of approximately ten years. As the review papers were published almost within the same period an apparent overlap between them were evident. Thus, the first research activity during the PhD period was an attempt to synthesize these review papers into an overview to explain how information sharing was characterized and utilized. These also served the purpose of identifying gaps for further research. The findings of this synthesis have been reported in Paper #1 together with a more detailed description of how the literature study was conducted.

It was identified in Paper #1 that the literature was lacking (or only discussed implicitly) a focus on how information sharing is linked to various planning decisions. Or, in other words, there is a need for a more conceptual framework for how to approach information sharing in practice – not only for grocery retailing but in general. Subsequently, another literature study was conducted to identify and synthesize facets of information sharing. Keywords like information “characteristics”, “facets”, “factors”, or similar wording useful to characterize information was applied during the literature search. Afterwards, it was evaluated how these facets could be incorporated with existing mapping tools to visualize the link between the information flow (described by the facets) and decision making. As no existing mapping tool was found adequate to include all facets a new mapping notation was proposed.

To demonstrate the applicability of the mapping notation a questionnaire was sent to two warehouses, stores, one transport provider, and some suppliers of vegetables (all part of the Norwegian research project Retail Supply Chain 2020) in August 2015. From the questionnaire, all facets of the shared information were derived as well as how the information was used at the receiving company. This was used to exemplify the applicability of the mapping tool, which has been reported in Paper #2.

The questions in the questionnaire were formulated as closed-ended questions (see Appendix A) and often with a predefined option to select answers to ensure comparison across the supply chain. Essentially, the questionnaire could also have been used as an interview guide for structured interviews. However, because of the geographical dispersion of the companies and to speed up the collection process, it was decided to distribute the questionnaire electronically. The involved companies had the option (and made use of it) to call if there were any doubts about the questions.

RQ 1b: What is the impact of information sharing in grocery retailing?

Value of information sharing is a well-established research stream and was also one of the main findings from Paper #1. However, the main part of the literature investigates non-industry specific supply chains and mostly develops and applies mathematical methods from operations research with limited empirical support.

To empirically explore the impact of information sharing in grocery retailing, a multiple case study with two cases was designed with the replenishment process as the unit of analysis. The case study method was selected because of its ability to handle multiple types of evidence (observations, documents, interviews, etc.) and strength in examining contemporary events in its natural setting (Voss et al., 2002; Yin, 2013). Additionally, a multiple case study was preferable over a single case as multiple case study enabled a comparison between cases using information sharing and cases without information sharing (the use of an automatic replenishment program was used as a proxy for information sharing). The collected data for the comparison took place between June and September 2015 and consisted of five interviews (see Appendix B for interview guide), data records from one of Norway's largest grocery retailer, two workshops, and observations at two stores for 14 days. The collected data was used to analyze the performance (from a food waste perspective) of the two different cases. The findings of the study have been reported in Paper #3.

As elaborated in the introduction, perishables are (and expected to continue) to be of major importance for future retailers. Paper #3 emphasized the challenge of how to handle these, and two subsequent studies were designed to examine how information sharing could contribute to solving this challenge. One study focused on the replenishment decision of perishables, and another concentrated on inventory allocation. The replenishment decision was selected because it is the most studied planning and control decision when examining the value of information (see Paper #1). Inventory allocation of perishables was selected because it is an important decision in divergent supply chains but has not received the same amount of attention in the literature (Karaesmen et al., 2011). The Norwegian grocery retailer also expressed an interest in these two areas which eased the issue of getting access to key personnel and data records.

Several replenishment policies, which use shared information, has been suggested to automate the replenishment process of perishables. However, these are often only evaluated in simple environments with one store or very few stores and with artificial data. Thus, to evaluate the impact of such policies in a more realistic context a discrete event simulation model mirroring thy inventory system of the Norwegian grocery retailer's downstream supply chain was established in Enterprise Dynamics® (interviews from Paper #3 was used to design the model). Discrete event simulation was the preferred simulation type as it enables representation of single events and has the ability to incorporate uncertainties, whereas e.g. system dynamics has a more aggregated flow and changes are most commonly made by changing different rates (order arrival rate, production rate, etc.) (Kleijnen, 2005).

Simulation is typically applied to examine the behavior of a system under a range of conditions where modeling of inventory systems is a common application (Croom, 2009). A virtual model of a supply chain offered the ability to evaluate the potential of information sharing across a number of predefined scenarios. Additionally, one of the scenarios included a newly developed heuristic for replenishing perishables based on shared information. The model is using point-of-sales data for more than 200 stores for one year and can change several parameters and thereby create the different scenarios. Basically, the scenarios could have been implemented in the stores and then evaluated through a multiple case study similar to Paper #3. However, the simulation was considered as a more cost-effective and more risk-free solution compared to a multiple case study. The findings of this simulation study have been reported in Paper #4.

To examine the impact of using shared information for inventory allocation it was found necessary to develop two new allocation policies due to limited research on this topic. To focus the research this study was split into two: firstly, development of inventory allocation policies and secondly the impact of using these policies. The applied method for developing the allocation policies can be classified as analytical mathematical research as they are built using formal logic (Wacker, 1998, p. 374). This work has been reported in Paper #5. The impact of using the policies has been evaluated using the above mentioned simulation model, and the findings are included later in this thesis in section 4.4.

3.1.2. Research Question 2
How do grocery retailers effectively align supply and stimulated demand?

As introduced in Chapter 1 the demand-stimulating activities include promotions, product introductions, and seasonal planning. Deciding how to approach and scrutinize these phenomena further was a result of several reasons – however, the driving one was that these type of activities have a medium-long planning horizon (1-8 month) and is considered as being part of the tactical planning level (Hübner et al., 2013). Tactical planning, within the Operations Management field, is often associated with sales and operations planning (Grimson and Pyke, 2007; Tuomikangas and Kaipia, 2014). Consequently, it was decided to examine if and how the tactical planning of demand-stimulating activities in grocery retailing could benefit from the mindset of sales and operations planning.

An examination of sales and operations planning in grocery retailing would be fairly explorative as this mindset originates from manufacturing. Following the terminology from Handfield and Melnyk (1998) the bulk of this type of research could be classified as descriptive (or even discovery). I.e. to create awareness and trying to explain what is happening. Case studies are particularly suited when exploring new and complex real-life events (Yin, 2013), where the context and experience are critical for understanding the phenomenon of interest (Barratt et al., 2011), and when research builds on existing theoretical frameworks (Voss et al., 2002). Therefore, the case study method was selected for this study.

An initial single case study was conducted at the Norwegian grocery retailer involving personnel from the purchasing, logistics, and the retail chain departments to provide a preliminary understanding of the tactical planning process. The findings from this case study have been reported in Paper #6. To expand the study and increase generalizability a multiple case study was afterward conducted involving three new additional cases. One premium grocery retailer from Great Britain, a discount grocery retailer from Norway, and a wholesaler from Finland was included. The findings from the multiple case study have been reported in Paper #7.

The unit of analysis was, both in the single and the multiple case study, the tactical planning process, and the primary technique for collecting data was through interviews. A total of ten interviews were conducted in relation these studies between November 2015 and August 2016. The interview guide is attached in Appendix C (similar interview guide was used for Paper #6). For a more thorough explanation of data selection, collection, and data analysis for these studies the reader is referred to Paper #7.

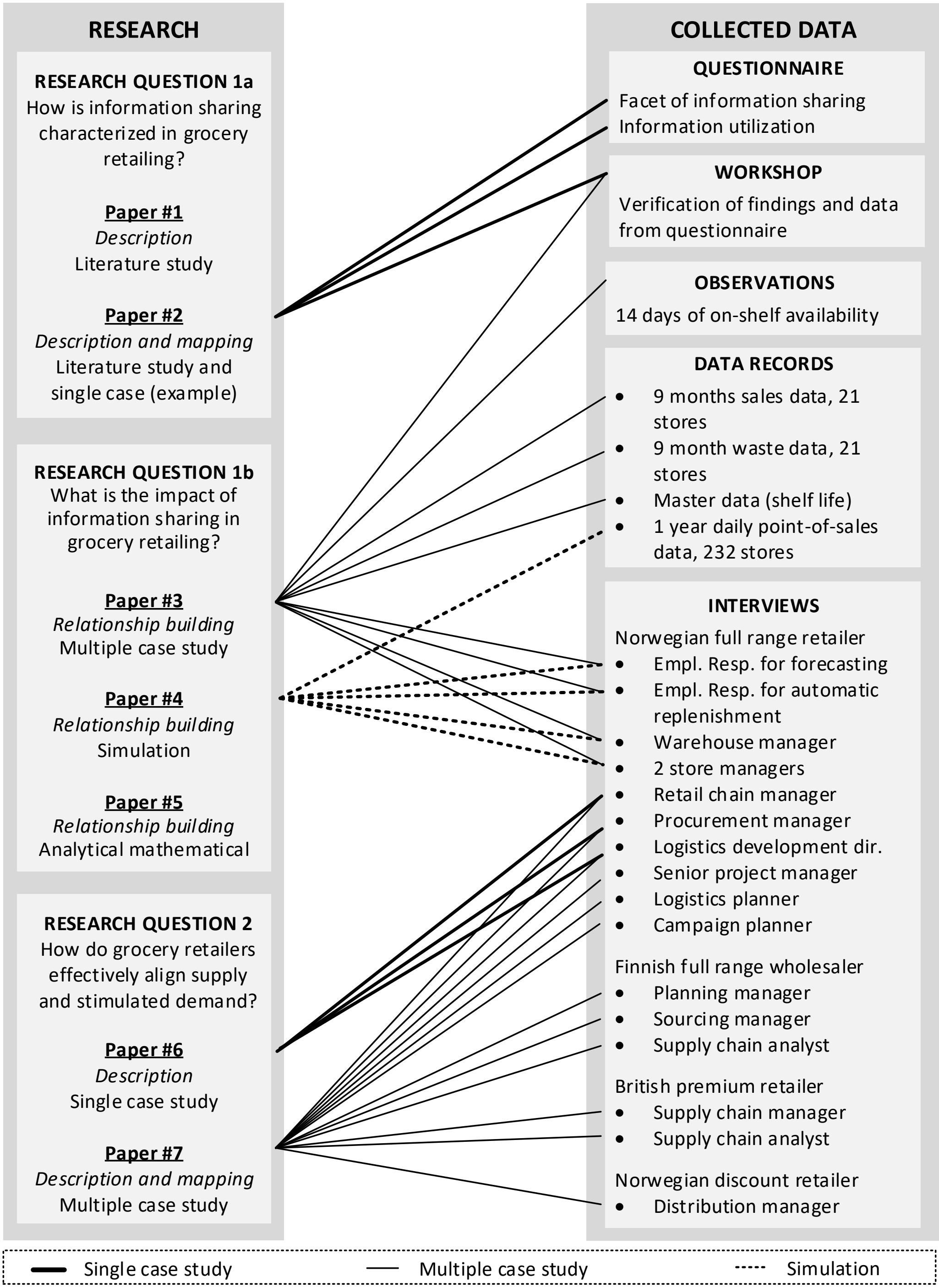

Figure 3.1: Relation between research questions, papers, methods, and collected data. The wording in italic is referring to the purpose of the research following the notation from Handfield and Melnyk (1998)

3.2. Research Quality

The traditional way of judging research quality is based on the premise of validity and reliability (Halldorsson and Aastrup, 2003). This is mainly intended for quantitative research, and as a corresponding response, the premise of *trustworthiness* is advocated to judge qualitative research (Golafshani, 2003; Lincoln and Guba, 1985; Shenton, 2004), and particularity also for qualitative research within logistics (Halldorsson and Aastrup, 2003). Some overlaps appear between the two premises (Hoepfl, 1997, Table 1) and even though differences might exist, the fundamental question (from the premise of trustworthiness): "*How can an inquirer persuade his or her audiences that the findings of an inquiry are worth paying attention to*?" (Lincoln and Guba, 1985, p. 290) appear highly relevant regardless of which premise that is used to evaluate quality. Furthermore, it is recommended and also common practice to evaluate case studies (which are qualitative) through the premise of validity and reliability (Voss et al., 2002; Yin, 2013). Thus, as this PhD study is using both qualitative (e.g. case study) and quantitative (e.g. simulation) methods, the premise of validity and reliability is found adequate to evaluate the research quality.

To elaborate validity sufficiently is it often divided further into three facets: construct validity, internal validity, and external validity (Yin, 2013). The following subsections present relevant examples of tactics that have been applied during this PhD study to account for these three facets of validity and reliability.

3.2.1. Construct Validity

Construct validity is the extent to which correct operational measures have been established for the concept being studied (Voss et al., 2002, p. 211). To adequately account for construct validity Yin (2013) proposed two critical aspects: (1) provide clear definitions of what to be investigated, and (2) show that the operational measures do indeed reflect what is intended to be investigated.

In this PhD study, definitions or explanations have been provided in all appended papers where some ambiguity might exist for the concepts being studied. The introduction also contains a brief description of the scope to account for surrounding topics. Also, Paper #2 contributed with a refined definition of the concept of information utilization.

The use of multiple sources of evidence (interviews, data records, observations), multiple interviewees, and review of field notes by interviewees were the main tactics used to ensure the second aspect of construct validity (Yin, 2013). All sources of evidence pointed towards the same conclusions. Additionally, 2-4 yearly workshops within the Retail Supply Chain 2020 project with all participating companies were conducted, as well as a review of all papers by the Director of Logistics Development from the Norwegian grocery retailer before submission. This contributed significantly to the verification of collected data and the subsequent findings throughout the whole PhD study.

For the simulation model, verification and validation tactics were used to ensure the model indeed reflected what was intended. The tactic of "calculating intermediate results" was used for verification (Kleijnen, 1995). Meaning, intermediate results in the simulation model (e.g. inventory level after receiving orders and satisfying demand) has first manually been calculated and then compared with the results from the simulation model. For validation of the model, the result of the "Baseline" scenario was compared and found similar to other simulation models from academic literature (see Paper #4).

3.2.2. Internal Validity

Internal validity is the extent to which causal relationships are established, whereby certain conditions are believed to lead to other conditions, as distinguished from spurious relationships (Yin, 2013, p. 46). In other words, if it is concluded that *Y* has taken place because of *X*, but overlooked that *Y* really happened because of *Z* there is a low internal validity. Hereby, it is also apparent that internal validity is more applicable as evaluation criteria for explanatory and causal studies and not necessarily in descriptive studies (Croom, 2009; Yin, 2013).

To ensure internal validity the use of 'pattern matching' and especially 'theoretical replication' has been one of the main tactics in this PhD study (Yin, 2013). In pattern matching, empirically based patterns are compared with predictions (e.g. from literature) made before collecting the data, which is a typical deductive approach (Karlsson, 2009). For example, in Paper #3, which compared two cases (one with and one without information sharing), the expected results were formulated based on literature before the data collection. Afterwards, the empirical findings were compared with this prediction. Additionally, in this particular study, the use of theoretical replication – search for contrasting cases – was used to select cases. Meaning, two different cases were intentionally selected, and different results were expected.

For the simulation study in Paper #4, the identification of causality is the main curiosity that drove the whole research. Here, causality is established by adjusting one independent variable at the time and then evaluating the causal effects on the dependent variables. Thus, not surprisingly simulation is generally found adequate to investigate causal relationships (Bertrand and Fransoo, 2009; Croom, 2009).

Lastly, Croom (2009) also advocate using method triangulation (e.g. case studies and simulation) and data triangulation (e.g. interviews and data records) to increase the support of proposed the-cause-and-effect. Referring to the previously shown Figure 3.1 emphasizes how both strategies have been used throughout this PhD study.

3.2.3. External Validity

External validity is the extent to which it is possible to generalize from the data and context of the research study to broader populations and settings (Cook and Campbell, 1979, p. 37). One could argue that quantitative research is more concerned with this type of generalizability while qualitative research instead generally seeks illumination (Hoepfl, 1997), however, it is still essential to define the domain in which the findings are valid (Yin, 2013).

For the case studies (see Figure 3.1), external validity has been accounted for by providing 'thick descriptions' of the context (Bryman and Bell, 2015). Eisenhardt (1989) also explains how within-analyses in multiple case studies often is (thick) descriptions of a case. These are useful for gaining insight and establishing the domain in which the findings are valid. Broadening or adding additional cases is useful to increase external validity further (Meredith, 1998; Voss et al., 2002), which was a tactic applied in relation to research question 2. Here, the findings and generalizability were substantially developed by widening the data collection from a single case study (Paper #6) to a multiple case study (Paper #7).

Similarly, the boundaries of the findings from the simulation study (Paper #4) are provided through the model description and specification of the assumptions. Thus, it is expected that the findings are valid for another *comparable* grocery retailer, i.e. with the same supply chain structure and same assumption as those in the simulation model.

3.2.4. Reliability

Reliability is the extent to which a study's operations can be repeated with the same results (Voss et al., 2002, p. 211). The goal of reliability is to minimize bias, so if another researcher with the same methods conducted the same study s/he would reach the same findings (Bryman and Bell, 2015; Yin, 2013).

Essentially, section 3.1 and the underlying sections describing the methods in each appended paper is an attempt to document the research process and make it possible for future researchers to conduct the study and thereby increase reliability (Shenton, 2004; Yin, 2013). More tangible examples of this are the previously mentioned interview guides and questionnaire in Appendixes. Additionally, by always having multiple authors involved in the research process contributed to a more vivid understanding and could be used as an argument for protecting against bias.

The results generated from the simulation model is also subject to reliability concerns due to its stochastic nature. Some of the values used in the simulation model come from probability distributions. Therefore, the output might differ slightly from time to time. To account for this, each scenario is run for one year and then average values were extracted. The length of one year was found to be sufficient to radically reduce the small variations.

Aligning Supply and Demand with Information Sharing 4

The purpose of this chapter is to present and discuss the findings in relation to Research Question 1 “How does information sharing contribute to align supply and demand in grocery retailing?” The research has been guided through the two sub-questions: 1a “How is information sharing characterized in grocery retailing” and 1b “What is the potential impact of information sharing”.

The chapter is organized around five sections. The first section is dedicated to the findings concerning Research Question 1a about characterizing information sharing. This acts as a frame of reference for the next three sections, which presents the findings to research question 1b concerning the impact of information sharing. Three substudies about the impact of information sharing have been conducted (one in each section). Specifically, two sub-studies examined the impact of utilizing shared information for the replenishment decision as this decision was expected to have a direct impact on the alignment of supply and demand. Additionally, because of the increasing importance of perishables (Nielsen, 2016b) and the challenge of reducing waste for these products (Kaipia et al., 2013), one substudy focused on perishable products. The third sub-study examined inventory allocation of perishables as this was found to be a rather understudied topic (Karaesmen et al., 2011), yet frequently occur in divergent grocery chains.

The first four sections focus on presenting the findings – the analysis from each paper (i.e. how the findings were made) is intentionally left out, and the interested reader is referred to the individual papers for this purpose. The fifth and final section of the chapter aims to consolidate and discuss the findings from the first four sections as well as emphasizing the theoretical contributions and the managerial implications.

4.1. Characterizing Information Sharing and Linking it to Information Utilization

As elaborated in Chapter 2 using shared information for planning is extensively studied in previous literature – not only for grocery retailing but all types of industries. Information sharing is concerned with making information available, while information utilization is to make use of that information. Through an examination of the literature four facets with underlying elements (see Table 4.1) were found applicable to characterize shared information between two or more companies.

Table 4.1: Facets of shared information

Facet		Underlying elements
Content	*What to share*	Type, aggregation, horizon, quality
Timeliness	*When to share*	Frequency, earliness
Source	*Whom to share with*	Supply chain actors, surrounding environment
Modality	*How to share*	Linked databases or EDI, electronical, physical, and informal

By using the four facets it is possible to characterize shared information. However, to provide an overview of the shared information in the supply chain a mapping notation for information flows has been developed which includes the four facets. The ability to visualize the four facets provides a detailed understanding of the information flow and more easily enables the identification of where the information could be useful.

The notation for information flow functions as an additional layer to existing mapping tools that maps the material flow. Particularly, it was found useful to combine the proposed notation with the Supply Chain Operation Reference (SCOR) model as the SCOR model easily shows the decision processes. These are essential as the received information should be linked to decision processes in order to utilize the information (Baihaqi and Sohal, 2013).

The notation for mapping the information flow encapsulates the four facets[1] and is illustrated in Figure 4.1. The form of the shape represents the *source* (where does the information originate from). The left side shows the *modality* (how is the information shared), while the right side shows the *timeliness* (frequency of exchange and how far in advance the information is shared). Lastly, the top part and the center of the shape shows the *content* (what information is shared and the aggregation and horizon of the information). The arrow in the bottom part indicates if the information is captured (output) or received (input).

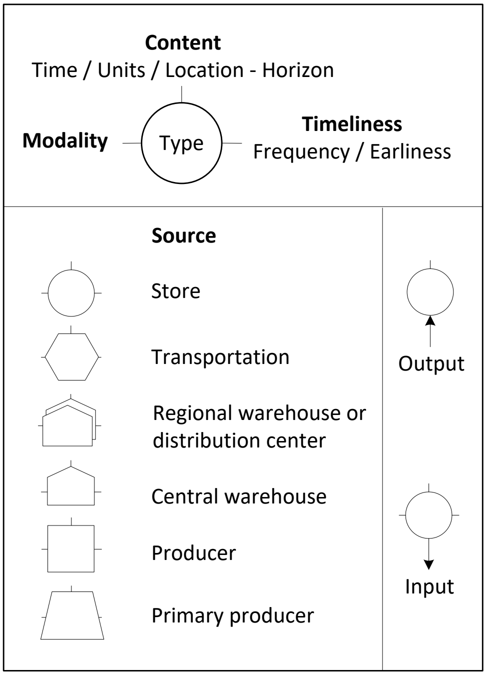

Figure 4.1: Notation for mapping the four facets of shared information

To highlight improvement areas for shared information Figure 4.2 adds some additional notation. If the shape is highlighted with a dotted line it shows that some information, which is already captured, can be utilized for at another planning process for decision-making. A black shape shows that some information is captured along the supply chain but currently not exploited anywhere. The two gray shapes indicate that a (1) new piece of information is captured and (2) utilized.

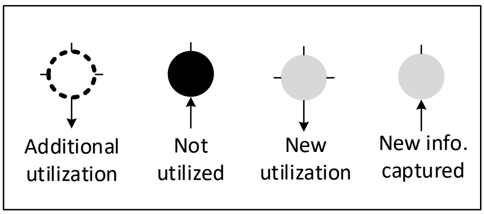

Figure 4.2: Additional notation for mapping improvement areas

Figure 4.3 shows a small example of the “Retail Deliver process” from the SCOR model and the proposed notation for the information flow (abbreviations are included in Table 4.2) for one of Norway’s largest grocery retailers.

[1] Information quality is not included as this was not reported as a challenge in the particular study

From left to right in Figure 4.3 it can be observed that to generate the stocking schedule (the process of scheduling resources to support replenishment) the store receives and uses forecasts for future promotions (F_p) from the central warehouse. It is received electronically through a portal, the information is shared six weeks in advance and updated every week. The aggregation is weekly (as the promotion is weekly), on a SKU level, and no specific aggregation in location is made. Lastly, the horizon is one week.

Besides the promotional forecast, the stores use two other inputs: planned orders (PO) and the sales information (S). First, the planned orders (PO) can be viewed electronically in a portal and is on a daily SKU level for the individual store. This information is updated daily and orders arriving the following day (1 day earliness) are possible to see. This information is mainly used to make small adjustments to for the near-future as it only covers the next day. Second, the sales information (S) is from the store itself, which in this case makes the modality rather informal, but considered every month when the stocking schedule is to be made. The aggregation is daily sales on a SKU level for that particular store.

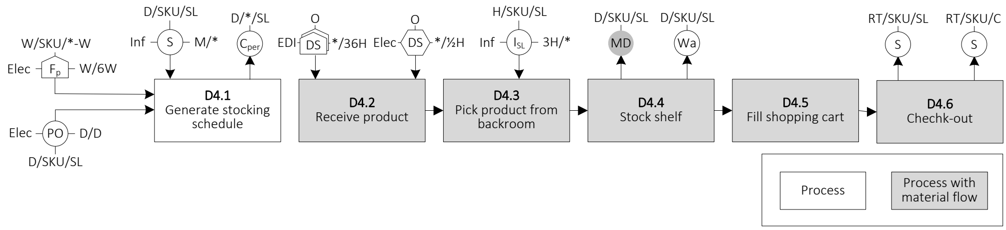

Figure 4.3: Information flow combined with SCOR Retail Deliver process (D4)

Table 4.2: Abbreviations in Figure 4.3

Time		**Units**		**Locations**		**Modality**	
RT	Real time	SKU	Stock keeping unit	C	Consumer	Inf	Informal
H	Hourly	B	Batch size	SL	Single location	Phy	Physical meeting
D	Daily	O	Order	R	Transportation route	Elec	Electronically via SMS, mail, portal, etc.
W	Weekly	TG	Temp. group (dry, chilled, frozen)				
M	Monthly					EDI	Linked databases or EDI

Information Type		**Special character**	
C_{per}	Capacity plan, personnel	*	Not applicable for that given information type
DS	Delivery status (time and quantity)		
F_p	Forecast, promotion information		
I_{SL}	Inventory level with shelf life		
MD	Markdown		
PO	Planned orders		
S	Sales		
Wa	Waste		

Figure 4.3 illustrates the material and information flow in order to deliver a retail product. The additional information layer to the SCOR model shows what type of information that is utilized at each process to reach a decision, as well as what information that currently is captured or potentially could be captured at each process. E.g., in the D4.3 process the employee will use information about the current inventory level when deciding which products to restock. This information is currently captured informally (left side of the shape), i.e. when the employee sees an empty shelf. However, if this information was captured electronically, the employee could access this information in the backroom and easily assess which products (in the whole store) that required immediate restocking.

Another example in Figure 4.3 is at the D4.4 process where the shelf is physically replenished. Currently, waste (Wa) is captured on a daily SKU level at each store. However, a potential information (as indicated with the gray color of the shape) to capture could be to daily record the SKUs that are marked down (MD) because of short shelf life at each store.

In Paper #2 a full-scale example of a warehouse, transportation provider, and stores are provided. The proposed notation comprehensively shows the information flow by including all four facets and the underlying elements. Because the notation splits the information flow into two: (1) where the information is captured and (2) where it is utilized, it is possible to identify current captured information which is not utilized. Additionally, because all facets are visually included it is easier to identify where the information could be used. E.g., information shared on a fine level of aggregation can be used for day-to-day operational decisions, whereas coarse information which is only shared infrequently should be used for either tactical or strategic planning decisions.

4.2. Impact of Utilizing Shared Information for Replenishment

The facets and proposed mapping tool in Section 4.1 are valuable to identify areas where shared information could be utilized. This section makes this next step and evaluates the impact of utilizing shared information - specifically for the replenishment decision. The evaluation is made by comparing the historical performance of two replenishment methods: one traditional where orders are placed manually in the stores to the warehouse, and one where the order is placed using an automatic replenishment system using shared information. For the manual replenishment, the order is based on a visual examination of the shelf (stock on hand) and the manager's expectations of future demand. The automatic replenishment system is managed by the warehouse and uses the same logic as presented in Section 2.2.2 (p. 13). Table 4.3 shows the shared information (from the stores to the warehouse) which is embedded in the system.

Table 4.3: Information facets and information utilization for the automatic replenishment system

Facets and elements of shared information			**Information utilization**
Content	*Type*	POS, waste	• POS, waste information and previous orders is used to calculate the inventory level at the stores
	Aggregation	Daily, SKU, store level	
Timeliness	*Frequency*	Daily	• A forecast is calculated based on POS
Source		Store	• An order is placed to raise the inventory level to the expected forecast plus safety stock
Modality		EDI	

The potential impact of applying automatic replenishment systems has been evaluated through traditional supply chain oriented measures such as ordering costs, inventory levels, on-time deliveries, bullwhip etc. (see e.g. (Daugherty et al., 1999; Potter and Disney, 2010; Stank et al., 1999; Yao and Dresner, 2008). However, it has been suggested that this kind of improved transparency also could reduce food waste in the food supply chain (Kaipia et al., 2013; Mena et al., 2014). This section presents a performance comparison of automatic and traditional replenishment based on food waste metrics in grocery stores. First, the impact on food waste is presented, and afterward, the impact on remaining shelf life (the freshness of the products) and availability is presented.

4.2.1. Food Waste

Data records (sales and waste) for a nine-month period was collected from 54 products in 21 stores. Products that were ordered manually in the store (without the use of automatic replenishment) were grouped as one scenario, and oppositely products that were ordered through automatic replenishment formed the second scenario. Additionally, to investigate the moderating effect of shelf life, each scenario was further clustered into different shelf life groups. Table 4.4 shows the number of products and data records (i.e. the number of product-store combinations) for each shelf life group for the two scenarios.

Table 4.4: Number of products and data records for each shelf life group

Shelf life [days]	**Number of products**	**Typical products in this group**	**Product-store data records**		
			Total	Manual	Auto. Repl
20-30	4	Eggs	78	29	49
31-50	13	Salmon, trout, cold cuts	225	106	119
51-70	16	Mayonnaise salads, fish cakes	270	111	159
71-90	9	Whole and sliced cheese	147	52	95
91-110	5	Butter, grated cheese	81	28	53
>110	7	Long-lasting bread and butter	133	43	90
Total	**54**		**934**	**369**	**565**

Figure 4.4 shows how the average food waste percentage is distributed for the two replenishment methods across the different shelf life groups. A general observation (irrespective of the replenishment method) is an increase in food waste for products with a medium-long shelf life. This could be caused by the limited attention to such products in the stores. These are normally regarded as “dry” products, and the expiration of these products are not perceived to be as important as for fresh food products.

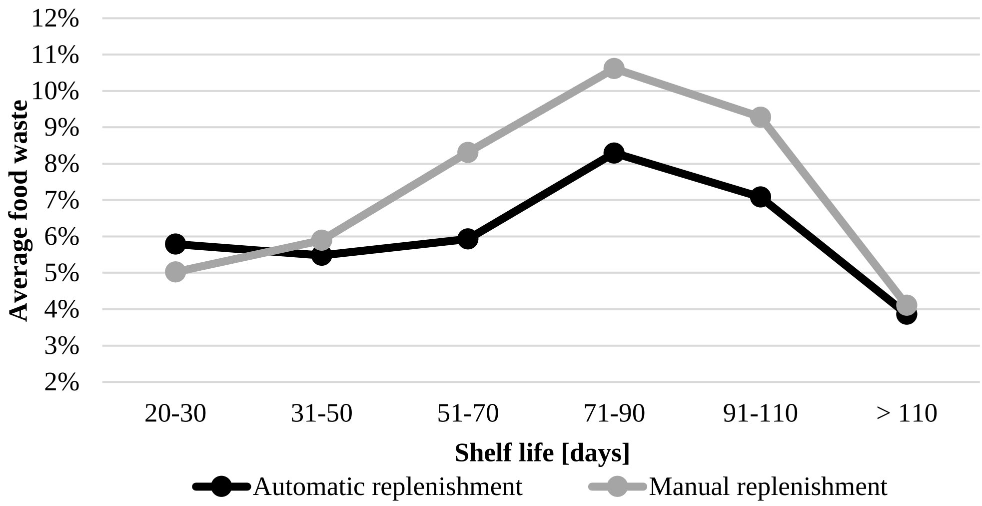

Figure 4.4: Food waste for a nine-month period using manual and automatic replenishment

Figure 4.4 also demonstrates a potential for food waste reduction through automatic replenishment. Except for products with a short shelf life below 30 days, the automatic replenishment system is favorable in all instances and especially for the products with a medium-long shelf life. The automatic replenishment system uses POS-information to trigger the new replenishment, and a better balance supply and demand can be obtained. For products with a short shelf life, the complexity of the replenishment decision is higher, and more information, e.g. when the current products on the shelf are expected to expire might be needed and will be discussed in Section 4.3. Nevertheless, across all shelf life groups, the food waste is 1.3 % points (17.8%) lower if the products are ordered through automatic replenishment.

4.2.2. Remaining Shelf Life and Availability

During a period of two weeks, two stores were visited each day to observe the remaining shelf life of four products in two stores – one with manual replenishment and one with automatic replenishment. Figure 4.5 shows the weighted average remaining shelf life for each day of the four products with the two different replenishment methods.

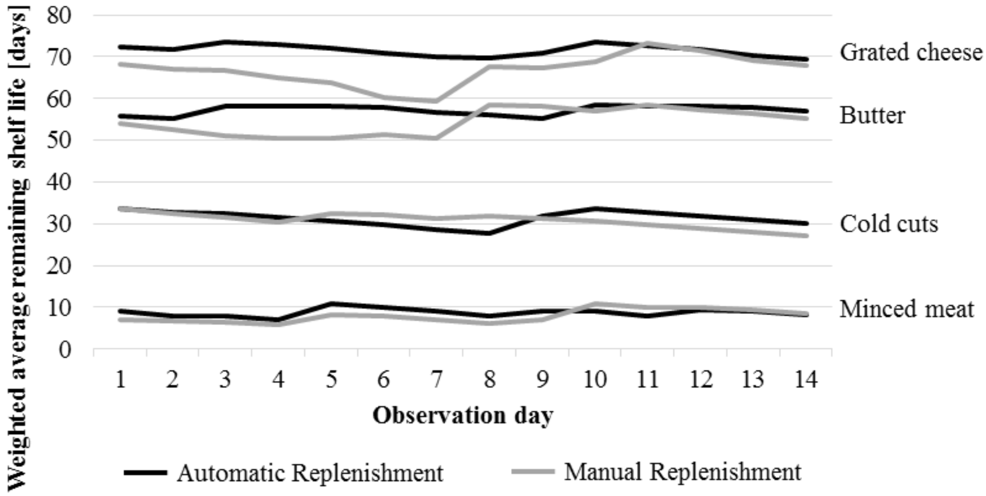

Figure 4.5: Weighted average remaining shelf life for four product with manual and automatic replenishment.

The findings from Figure 4.5 is similar to Figure 4.4. The improvement in *remaining* shelf life (freshness) is highest for the products with a medium-long shelf life, and across all products, the remaining shelf life was found to be 5.2% higher if ordered with automatic replenishment. Additionally, during two weeks of visits no stock-outs were observed indicating that the automatic replenishment system did not compromise a high availability. This is further supported by statements from the grocery retailer, which explained that stores that implemented automatic replenishment generally experienced a 2-3% increase in availability. The grocery retailer also found that the automatic replenishment required less training and experience compared to manual order – a clear benefit during sickness and vacations.

4.3. Impact of Utilizing Shared Information for Replenishment of Perishables

As highlighted in Section 4.2 using shared POS and waste information for the replenishment decision can on average reduce food waste by 1.3% point. For products with a shelf life below 30 days it might be necessary to share additional information and particularly the remaining shelf life of the products at the stores to make better replenishment decisions (Broekmeulen and van Donselaar, 2009; Duan and Liao, 2013). Accordingly, the purpose of this section is to evaluate the impact of sharing and utilizing remaining shelf life information (i.e. inventory level with remaining shelf life) for replenishment of products with shelf life below 30 days in a divergent supply chain.

To make use of the remaining shelf life information more advanced inventory policies are needed. Here, the EWA policy (introduced in Section 2.2.3, page 15) is applied as well as a proposed modified version called the EWA_{SS} policy (will be introduced below) to account for the difficulties of safety stocks in the original EWA policy. These two policies are compared to a baseline scenario that uses an (R,s,nQ) policy found in traditional automatic replenishment systems (Potter and Disney, 2010).

Thus, in total three scenarios are evaluated (Table 4.5 summarizes the facets of the shared information and how it is utilized):

1) Traditional automatic replenishment (Baseline)
2) Automatic replenishment with EWA policy (EWA)
3) Automatic replenishment with a modified EWA policy (EWA_{SS})

Table 4.5: Information facets and information utilization for replenishment of products with a shelf life below 30 days

Facets and elements of shared information			Information utilization
Content	*Type*	POS and waste information Inventory level with remaining shelf life	• POS, waste information and previous orders are used to calculate the inventory level at the stores for the baseline scenario. • The remaining shelf life information is used in the EWA and EWA_{SS} to calculate the replenishment quantity
	Aggregation	Daily, SKU, store level	
Timeliness	*Frequency*	Daily	
Source		Store	
Modality		EDI	

4.3.1. Modified EWA policy – the EWA_{SS} policy

The traditional automatic replenishment system determines the order quantity based on expected demand + safety stock while the EWA policy additionally adds the expected amount of products outdating to the order quantity. Obviously, if ten products are expected to outdate (during review + lead time) the EWA policy simply orders ten extra products. However, those ten products basically function as an additional buffer (safety stock) *if* those ten products outdate. In other words, situations that are difficult to manage, i.e. high uncertainty in demand and risk of products outdating, will continuously receive a relatively large amount of safety stock to accommodate for this. Therefore, it is proposed (see Paper #4) to modify the EWA policy.

The difference between the EWA policy and the EWA_{SS} policy is in regards to the safety stock – hereof the name EWA_{SS}. Basically, in the EWA_{SS} policy each time an order quantity should be determined the number of products outdating is compared to safety stock (SS) value. If the number of products outdating are larger than SS the order quantity equals expected demand + products outdating. Otherwise, the order quantity equals: expected demand + SS. Thereby, the risk of products outdating and the uncertainty in demand is covered by the same buffer – either the number of products outdating or SS, depending on which one is the biggest. Hence, no "additional" buffer is added as in the original EWA policy. Mathematically it is formulated as:

$$if\ I_t - \sum_{i=t+1}^{t+R+L-1} \hat{O}_i < \sum_{i=t+1}^{t+R+L} E[D] + SS \quad \text{then:}$$

$$if\ SS < \sum_{i=t+1}^{t+R+L-1} \hat{O}_i \quad \text{then:}$$

$$Q_t = \left\lceil \frac{\sum_{i=t+1}^{t+R+L} E[D] + \sum_{i=t+1}^{t+R+L-1} \hat{O}_i - I_t}{B} \right\rceil \qquad (2a)$$

$$if\ SS \geq \sum_{i=t+1}^{t+R+L-1} \hat{O}_i \quad \text{then:}$$

$$Q_t = \left\lceil \frac{\sum_{i=t+1}^{t+R+L} E[D] + SS - I_t}{B} \right\rceil \qquad (2b)$$

Where the safety stock (SS) is calculated as the standard deviation of forecast errors during review interval plus replenishment lead time times a safety factor ($\sigma_{R+L} \cdot k$) (Silver et al., 1998). Otherwise, the notation is the same as for Equation 1, page 16.

4.3.2. Simulation model

To evaluate and compare the performance of the three scenarios a discrete event simulation model was built. Simulation models are typically found in the literature to evaluate different inventory scenarios as they provide a risk-free environment (Croom, 2009). The simulation model mirrors a downstream part of Norway's largest grocery retailer. One warehouse and 232 stores, which were divided into 21 groups depending on the mean sales per week (5 to 696 units sold per week), number of deliveries per week (2 to 6), and the store concept (discount, premium, hypermarket). Based on POS-information of one product from the 232 stores daily demand distributions were fitted and used as input for the simulation model.

The simulation model functions by a number of events at the warehouse (W) and at the stores (S). Figure 4.6 and Table 4.6 outlines each event and how they relate to each other. At event S3 the EWA, EWA_{SS} and a baseline replenishment policies are implemented and can be changed between each simulation run. Besides the three events at the warehouse and the three events at the stores, all products are reduced with one day of remaining shelf life (RSL) for every 24 hours. A more thorough explanation of the assumptions, verification, and validation of the simulation model is included in Paper #4.

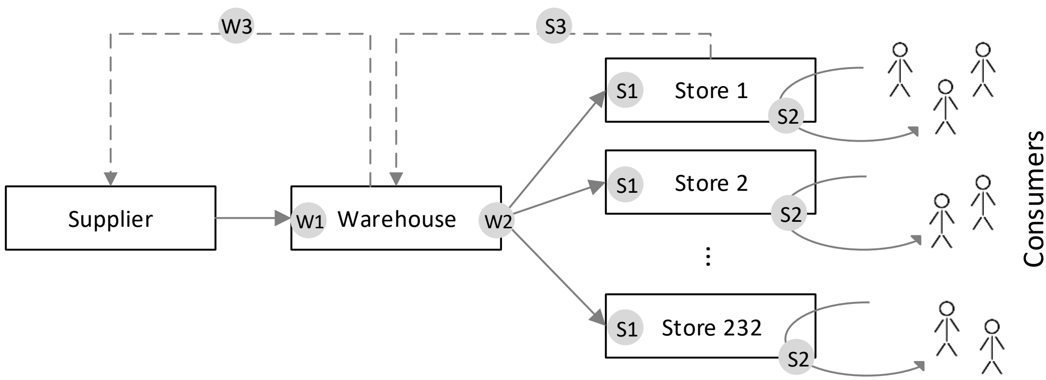

Figure 4.6: Relation between events in the simulation model

Table 4.6: Events in the simulation model

Events at the warehouse	Events at stores
W1: Goods arrive and are added to inventory To reflect the processing time and delivery time from the supplier goods are added to the inventory 38 hours after they are ordered.	*S1: Goods arrive and are added to inventory* To reflect the processing time at the warehouse and delivery time from the Norwegian grocery retailer goods are added to the inventory 38 hours after they are ordered, e.g. an order placed Monday afternoon is added to the inventory Wednesday morning
W2: Satisfy demand Orders from the stores are collected and shipped to the stores. In case of shortage, a first-come-first-service principle is followed, and the FIFO principle is applied for stock depletion.	*S2: Satisfy demand* A random value is picked from the fitted probability distribution. The α value specifies how big a proportion of that demand that is depleted with FIFO (products with the lowest RSL at the front of the shelf) and the remaining part is issued with LIFO (products at the back of the shelf)
W3: Replenishment If it is an ordering day an exponential smoothing forecast with weekly seasonality is generated covering the review and delivery time. It is assumed that the warehouse always has access to its own RSL information and the EWA_{SS} policy is always applied.	*S3: Replenishment* If it is an ordering day for the particular store an exponential smoothing forecast with weekly seasonality is generated covering the review and delivery time. Depending on the selected replenishment policy the required number of batches are calculated, and an order is placed.
Night: Reduce RSL and record performance All products with two days RSL are removed from inventory, and the RSL of all other products is reduced with one day. Information about inventory level, average RSL, fill rate, and amount wasted is recorded.	*Night: Reduce RSL and record performance* All products with one day RSL are removed from inventory, and the RSL of all other products is reduced with one day. Information about inventory level, average RSL, fill rate, and amount waste is recorded.

Each scenario was run for one year, and the shelf life of the product was gradually increased (with one day) from 4 days of shelf life to 20 days of shelf life. These limits were made because the total lead time through the supply chain is at least 2 x 38 hours and products with a shelf life less than four days would have expired before they reached the stores. Additionally, no changes were observed with a shelf life above 20 days.

To make the simulations closer to reality a batch size of 9 SKUs (between stores and warehouse) and a mix between FIFO and LIFO depletion was implemented at the stores (Janssen et al., 2016). Specifically, 90 % of the demand in the stores was depleted following FIFO and the remaining 10 % following LIFO. These numbers are intended to symbolize that 90 % of the consumer will pick the products in front, while 10 % will search for products at the back of the shelf with a longer remaining shelf life. Appendix D contains a sensitivity analysis of this parameter with 80% and 100% FIFO. The warehouse always follows a FIFO depletion towards the stores.

4.3.3. Comparison of scenarios

The scenarios are compared against the identified measure found relevant for grocery retailing (see Table 2.3, page 25). Figure 4.7 shows the achieved fill rate, i.e. the fraction of demand that has been fulfilled and is here used to indicate the availability. The two EWA policies are superior to the baseline scenario for products with a shelf life up to around 11 days of shelf life, and afterward, no significant differences exist. The mean difference from 4 to 11 days, between the baseline and the EWA_{SS} is 8.1% points (10.3% higher), while this is 13.8% points (17.7% higher) between the baseline and the EWA policy. It is not surprising that the EWA policy provides a higher availability than the EWA_{SS} policy because the total buffer (safety stock + number of products outdating) in the EWA policy is larger than the total buffer in the EWA_{SS} policy. This corresponds to using a higher safety factor (k) to achieve a higher availability.

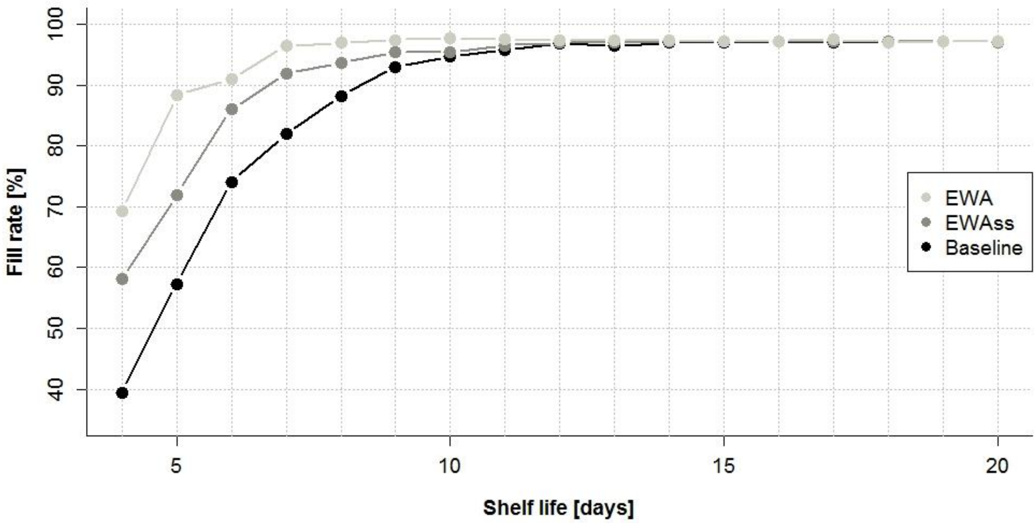

Figure 4.7: One year average fill rate across all stores

Another way to compare availability is to use the ready rate which specifies the fraction of time (number of days where the stores are open) has been positive – in other words, the amount of days where the stores are "ready" (Silver et al., 1998). Even though it does not consider the required volume it is still of interest to understand the performance. As shown in Figure 4.8 the EWA and EWA_{SS} policy almost provide the same ready rate (except when the shelf life is five days). This indicates that (1) the EWA_{SS} policy will provide the first consumer(s) with products but towards the end of the day run out of stock. However, considering that consumers have a higher willingness to substitute between perishables products (Van Woensel et al., 2007), this might not be critical. (2) the high ready rate could indicate that the EWA_{SS} policy has adequate timing for ordering, but the order quantity (considering the lower fill rate) in some case might be too small.

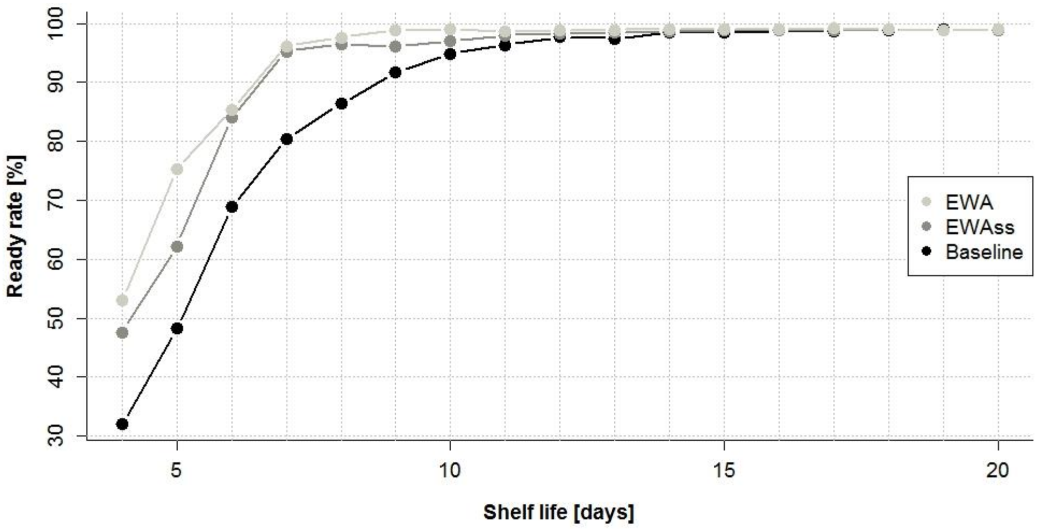

Figure 4.8: One year average ready rate across all stores

Even though the waste percentages are (too) high for all three policies, as depicted in Figure 4.9 when the shelf life is short the EWA_{SS} policy generally shows its strength when considering this measure. For products with a shelf life between 4 to 11 days the average difference between the baseline and the EWA policy is -1.2% point (3.4% lower), whereas the difference between the baseline and the EWA_{SS} is -3.6% point (10.7% lower). The biggest improvement for the EWA policy (compared to the baseline) is for products with a shelf between 4 and 5 days, but here the waste levels are still over 50% and when the shelf life increases to 6 days or higher the baseline and EWA policy is very similar. Thus, the EWA policy provides a higher availability, but the EWA_{SS} policy provides a more balanced performance of supply and demand by improving both availability and waste with approximately 10% in both measures compared to the baseline.

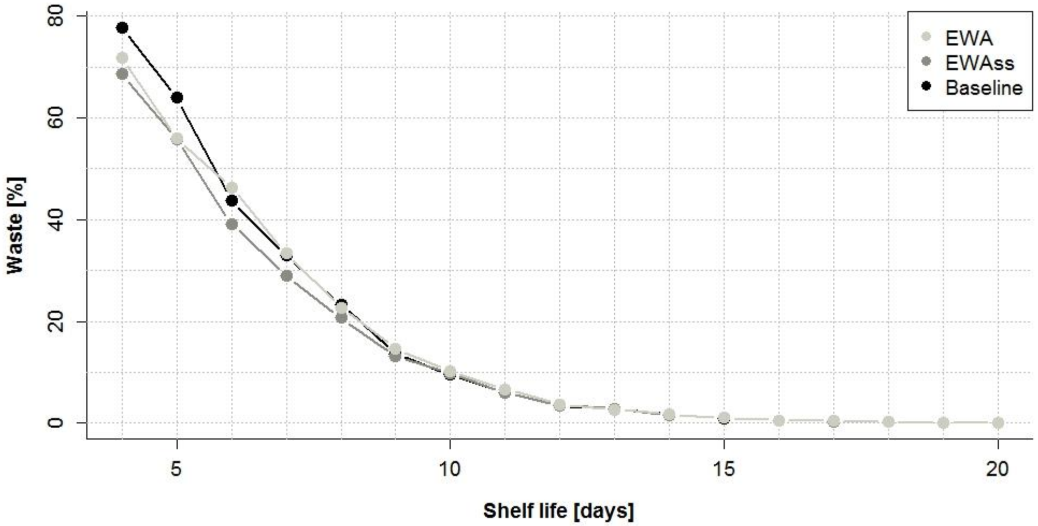

Figure 4.9: One year average waste across all stores and warehouse

Providing high availability of products with a short shelf life in all stores necessitates that the stores get frequent deliveries. Figure 4.10 shows how the two EWA policies require significantly more deliveries than the baseline scenario. Between a shelf life of 4 to 11 days, the EWA policy has on average used 7,430 (28% %) more deliveries, whereas the EWA_{SS} policy used 4,818 (18 %) more deliveries than the baseline. From a sustainability perspective this, of course, needs to be balanced and evaluated to ensure the savings in waste and gains in availability justifies the increased amount of deliveries. However, the simulation model only used the allowed number weekly deliveries for each store, and the figure does not indicate a trip with a single product on the truck. Thus, the truck is likely to go to the store with other products anyway.

An increased number of deliveries, however, reflects an increased handling cost. Meaning, that the products need to be picked and packed more often at the warehouse and store personnel have to replenish the shelf more often. This has to be measured against increased stock rotation, reduced waste and the ability to deliver fresher products to the consumers.

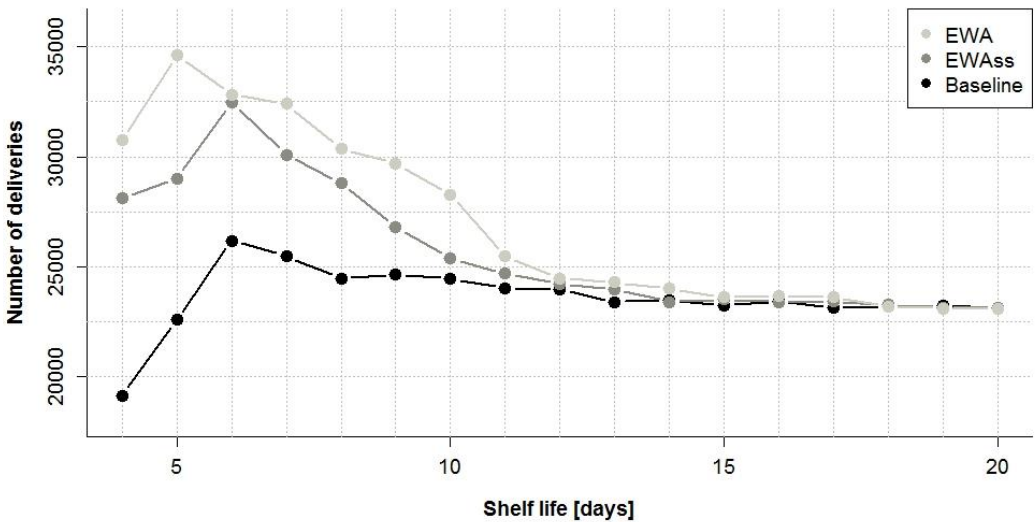

Figure 4.10: Total number of deliveries for one year for all stores and warehouse

A frequently used measure for evaluating inventory policies is the holding cost, which is the carrying cost times the inventory level. To give a more general evaluation (and not multiplying the result with an arbitrary carrying cost) Figure 4.11 shows the average inventory level including both the warehouse and all stores. It is obvious from the figure that the higher availability from the EWA policy does not come for free reflected by the higher inventory levels. Between the shelf life of 4 to 11 days, the inventory level is on average 1,307 units (17.8 %) higher for the EWA policy and 22 units lower (-0.3 %) for the EWA_{SS} compared to the baseline. Not only does this indicate that the EWA_{SS} policy has less capital tied up in inventory but it also shows that the required capacity (warehouse, shelves, and backroom at the store) is less. This lower inventory level together with decreased waste should favor the EWA_{SS} policy compared to the EWA policy.

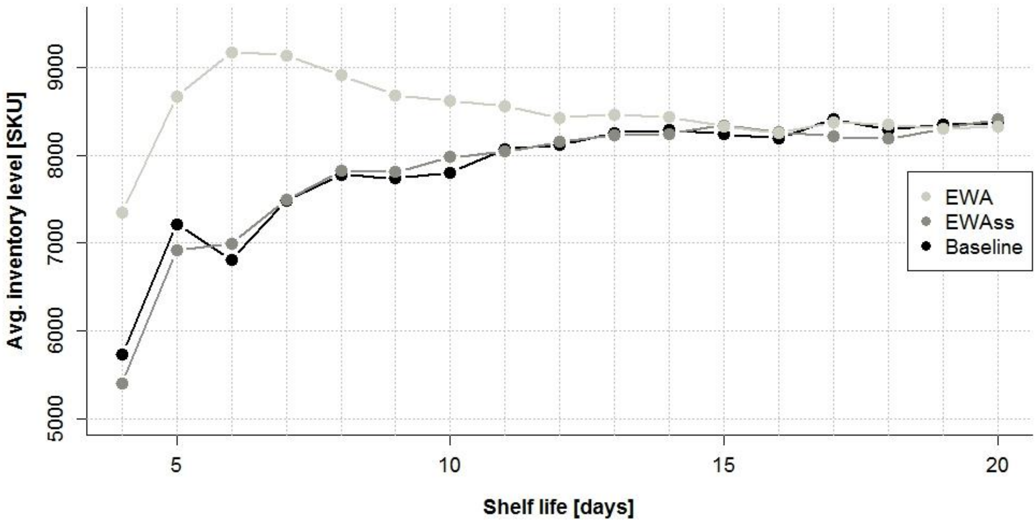

Figure 4.11: Average inventory level for one year across all stores and warehouse

The last performance measure from Table 2.3 (page 25) is freshness or remaining shelf life of the products in the stores. The three policies provide a fairly even performance on this measure. Figure 4.12 shows the weighted average remaining shelf life in the stores for products with a shelf life between 4 and 11 days (after 11 days no changes are seen). The EWA policy is 1.1% higher while the EWA_{SS} policy is 1.3% higher compared to the baseline. Thus, no major difference can be observed for this performance measure.

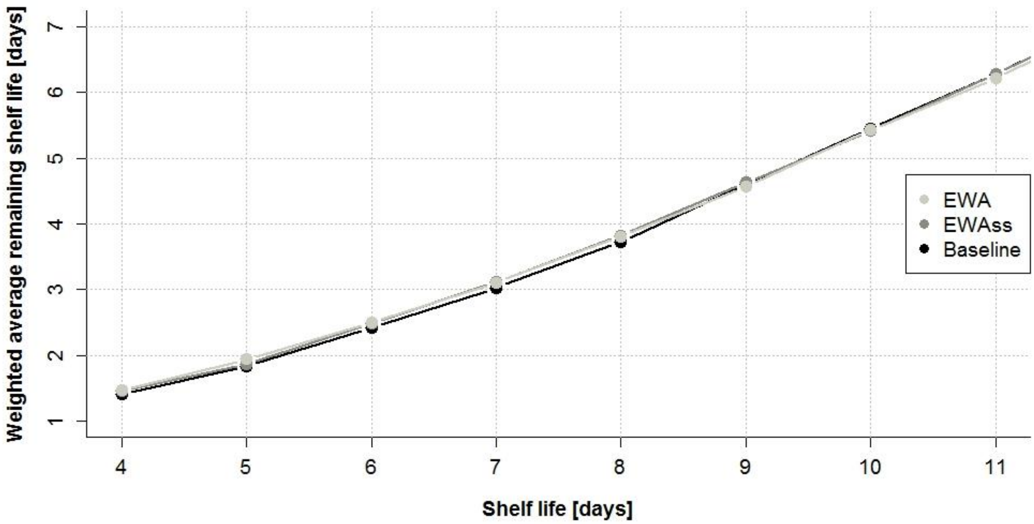

Figure 4.12: Weighted average remaining shelf life for one year across all stores

Table 4.7 and Figure 4.13 summaries the findings. In Figure 4.13 the fill rate and the waste are compared, and the numbers refer to the shelf life. Ideally, the best performance it at the top left corner, with high fill rate and low waste. The three scenarios approach this corner at a different pace. As observed in this figure (and from Figure 4.7 to Figure 4.12) the biggest difference in performance across the three scenarios is for products with a shelf life of 4 to 11 days. Thus, a summary of these results is presented in Table 4.7.

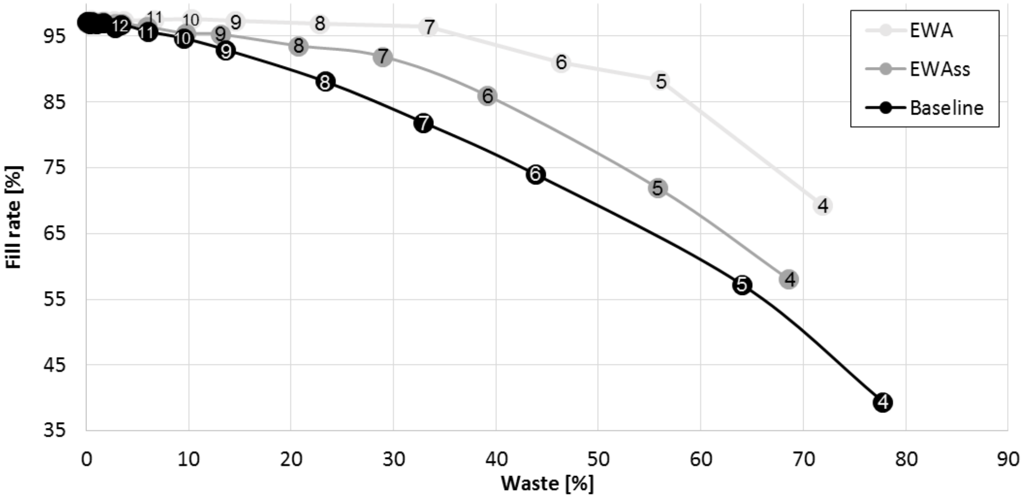

Figure 4.13: Average waste for one year across all stores and warehouse and average fill rate across stores. The numbers on the graph refer to the shelf life of the products.

Table 4.7: Average performance improvement for products with a shelf life between 4 and 11 days

Performance indicator	**EWA vs. Baseline**	**EWA$_{SS}$ vs. Baseline**
Availability (fill rate)	+17.7% (+13.8% point)	+10.3% (+8.1% point)
Availability (ready rate)	+17.5% (+13.1% point)	+13% (+9.7% point)
Waste	-3.4% (-1.2% point)	-10.7% (-3.6% point)
Number of deliveries	+28%	+18%
Average inventory level	+17.8%	-0.3%
Freshness	+1.1%	+1.3%

From Figure 4.13 it can be observed that the EWA$_{SS}$ policy aligns supply and demand to a greater extent than the baseline scenario – all data points between 4 to day 11 days of shelf life is located higher (higher fill rate) and more to the left (less waste). The data points from the EWA policy is very high compared to both the baseline and the EWA$_{SS}$ policy, but they are in some cases also located more to the right (higher waste) or right above (same waste). A further discussion of how to interpret and apply these findings is included in Section 4.5.

4.3.4. Sensitivity analysis

The results in Figure 4.7 to Figure 4.13 all have a FIFO depletion of 90% and a batch size (between the stores and the warehouse) of 9 SKUs in one batch. Appendix D includes a sensitivity analysis of changes in the FIFO depletion from 80 to 100% as well sensitivity from changing the batch size from 6 to 12 SKUs per batch. Generally, the performance is very robust to changes in depletion; only the waste reduces marginally as the depletion goes towards 100% FIFO. This makes sense as more "old" products are sold and ultimately less is wasted.

The number of deliveries and inventory level is affected by changes to the batch size. The smaller batch size, the lower inventory level and higher amount of deliveries. This is reasonable as a small batch size enables an even finer balance between supply and demand – achieved by more frequent (small) deliveries, which will reduce the inventory level. Small changes to waste is observed by changing the batch size. Generally, a lower batch size can slightly reduce the waste, which is coherent with previous findings in the literature (Eriksson et al., 2014). Here, reducing the batch size from 9 to 6 reduced waste with 0.7% point for both the EWA_{SS} policy and EWA policy across shelf lives from 4 to 20 days.

4.4. Impact of Utilizing Shared Information for Inventory Allocation of Perishables

Section 4.2 and 4.3 has focused on the impact of utilizing shared information for the replenishment decision. However, during the literature study it was found that using shared information for inventory allocation decisions has not received much attention in the academic literature (see Table 2.1, page 12) and especially for allocation of perishables (Karaesmen et al., 2011). For perishables, inventory allocations are concerned with which requesting store that should receive the oldest or newest products (age allocation), and in case of shortage how to allocate the available stock on hand from the warehouse to these stores (volume allocation).

To benefit from shared information two situations for inventory allocations of perishables has been developed: (1) where access to inventory information from the store is available, and (2) access to remaining shelf life of the products at the stores (guidelines for these allocations are introduced below). Essentially the first situation requires the same amount of information as a traditional automatic replenishment system, while the second requires the same as for the EWA or EWA_{SS} policy to function.

To measure the impact of utilizing shared information the performance of the two proposed inventory allocations is compared against a random allocation policy. Here the products allocated to the requesting stores are randomly picked from the warehouse, and in case of shortage, a first come first serve principle is followed. Thus, the three policies to compare are listed below, and Table 4.8 summarizes the facets of the shared information and how it is utilized.

1) Proposed allocation with access to inventory levels (Inv. Info)
2) Proposed allocation with access to remaining shelf life information (RSL Info)
3) Random (Baseline)

Table 4.8: Information facets and information utilization for inventory allocation

Facets and elements of shared information			Information utilization
Content	*Type*	POS, inventory level with/without remaining shelf life	• POS and inventory information are used to calculate expected demand • Two separate policies are evaluated to calculate the volume and age allocation (see Table 4.8 to 4.10) • Remaining shelf life information is used to estimate the number of products soon to outdate
	Aggregation	Daily, SKU, store level	
Timeliness	*Frequency*	Daily	
Source		Store	
Modality		EDI	

4.4.1. Proposed guidelines for inventory allocations

For situations with a shortage, it is necessary to make a *volume allocation*, i.e. calculating how the stock on hand is divided into quantity allocations (QA) for the stores. For the two proposed policies calculating QA1 and QA2 provides these allocations and can be determined using the three-step procedure in Table 4.9 and Table 4.10.

Table 4.9: Determine quantity to be allocated with access to inventory level (QA1)

***Step 1:** Calculate the average supply chain wide service level*	$SLA1_{SC} = \frac{\sum I_i + BI_0}{\sum BQ_i + \sum I_i}$; for all stores *i* $SL1_i = \frac{I_i}{I_i + BQ_i}$; for each individual store
***Step 2:** Calculate the possible supply chain wide service level*	$SLP1_{SC} = \frac{\sum I_i + BI_0}{\sum BQ_i + \sum I_i}$; for all *i* where: $SL1_i < SLA1_{SC}$
***Step 3**: Calculate allocation quantities*	$QA1_i = \frac{(I_i + BQ_i) SLP_{SC} - I_i}{B}$; for all *i* where: $SL1_i < SLA1_{SC}$

Table 4.10: Determine quantity to be allocated with access to remaining shelf life information (QA2)

***Step 1:** Calculate the average supply chain wide service level*	$SLA2_{SC} = \frac{\sum I_i + BI_0}{\sum BQ_i + \sum I_i + \sum R\hat{O}_i}$; for all stores *i* $SL2_i = \frac{I_i}{I_i + BQ_i + R\hat{O}_i}$; for each individual store
***Step 2:** Calculate the possible supply chain wide service level*	$SLP2_{SC} = \frac{\sum I_i + BI_0}{\sum BQ_i + \sum I_i + \sum R\hat{O}_i}$; for all *i* where: $SL2_i < SLA2_{SC}$
***Step 3**: Calculate allocation quantities*	$QA2_i = \frac{(I_i + BQ_i + R\hat{O}_i) SLP2_{SC} - I_i}{B}$; for all *i* where: $SL2_i < SLA2_{SC}$

Where:

B:	Batch size (order multiplier between the store and the warehouse)
Q_i:	Order quantity (in batches) from store *i*
I_i:	Current inventory level at store *i* (in SKUs)
L_i:	Lead time for store *i*
R_i:	Days till next review at store *i*
A_i:	Amount of "old" products at store *i* with remaining shelf life less than or equal to R+L (i.e. products that are soon-to-outdate)
WA_i:	Weighted average remaining shelf life of A_i at store *i*
RA_i:	A_i / WAi

Afterwards, the *age allocation* is made by listing the stores using $Rank_1$ (with access to inventory level) or $Rank_2$ (with access to remaining shelf life information)

$$Rank_1 = \frac{BQ_i+I_i}{L_i+R_i} \qquad (3)$$

$$Rank_2 = \frac{RA_i}{BQ_i+I_i} \qquad (4)$$

More details of the two inventory allocations can be found in Paper #5. However, the general principle is summarized in Table 4.11:

Table 4.11: Guidelines for inventory allocations of perishables

No shortage at warehouse	• List stores after $Rank_1$ • Highest value receives oldest products	• List stores after $Rank_2$ • Lowest value receives oldest products
Shortage at warehouse	• Calculate QA1 • List stores after $Rank_1$ • Highest value receives oldest products	• Calculate QA2 • List stores after $Rank_2$ • Lowest value receives oldest products
	With inventory information	**With remaining shelf life information**

In simple wording, the allocation policy with access to inventory information distributes the oldest products (age allocation) to stores that are expected to have the highest demand until next delivery to increase the chance of selling these products before they outdate. In case of shortage, the policy follows the fair share rule by equalizing the risk of stock-out among all requesting stores (volume allocation). For the allocation policy with access to remaining shelf life the stores with the lowest risk of having products that outdates, relative to the expected demand, receive the oldest products (age allocation). Again, to increase the chance of selling these products before they outdate. In case of shortage (volume allocation), the same fair share allocation rule is applied, but additional weight (i.e. they receive more products) is given to stores with a high risk of products outdating.

4.4.2. Comparison of scenarios

The performance of the three policies was evaluated using the same discrete event simulation model as introduced in Section 4.3.2 (page 45). Specifically, the three different allocation policies were implemented in event W2 (see Table 4.6, page 46). The average performance of one year simulation run is shown in Figure 4.14 to Figure 4.17. For all simulations, the baseline replenishment policy is used together with a batch size of 9 and a 90% FIFO depletion.

Figure 4.14 depicts the fill rate across all stores while Figure 4.15 depicts the waste level. Both policies provide similar improvements in both performance measures. For products with a shelf life between 4 to 11 days an average increase in the fill rate of 3.3% (2.6 % point) and a reduction of 3.8% (1.2 % point) waste compared to the baseline scenario is observed for both policies. Furthermore, from Figure 4.14 it can be seen that the improvement in fill rate decreases but continues for products with a shelf life longer than 11 days. This most likely results from improvements in *volume* allocation, whereas both the *age* and *volume* allocation contributes to the higher fill rate for products with a lower shelf life.

Obviously, the magnitude of these numbers is not nearly as exciting as the impact of utilizing shared information for the replenishment decision as discussed in the previous section. However, compared to the findings in Section 4.2 (page 40) the reduction in waste was found to be 1.3% point, which can result in significant financial savings when placed in a bigger context. Additionally, in that study, the perceived improvement in availability was stated to be between 2-3% – again a number with a similar magnitude as observed here for the allocation decision

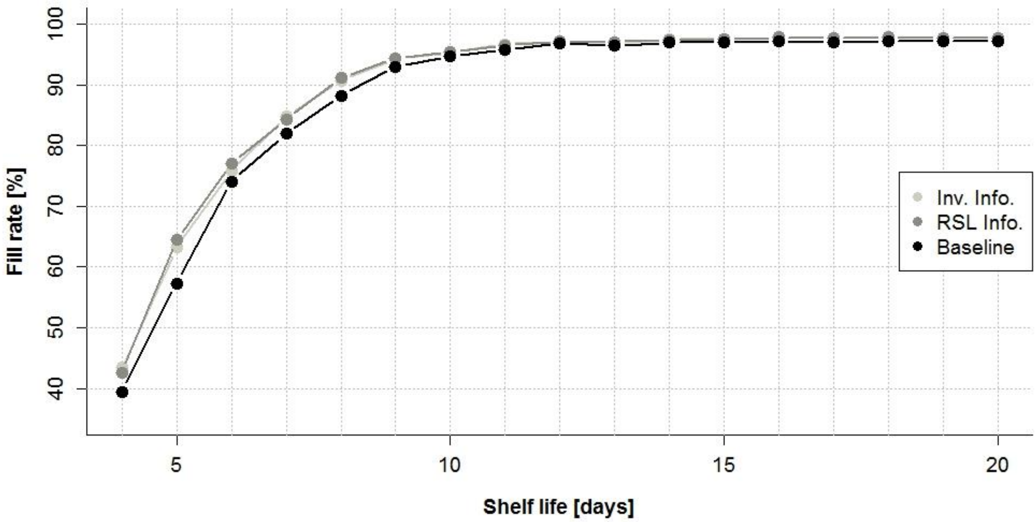

Figure 4.14: One year average fill rate across all stores

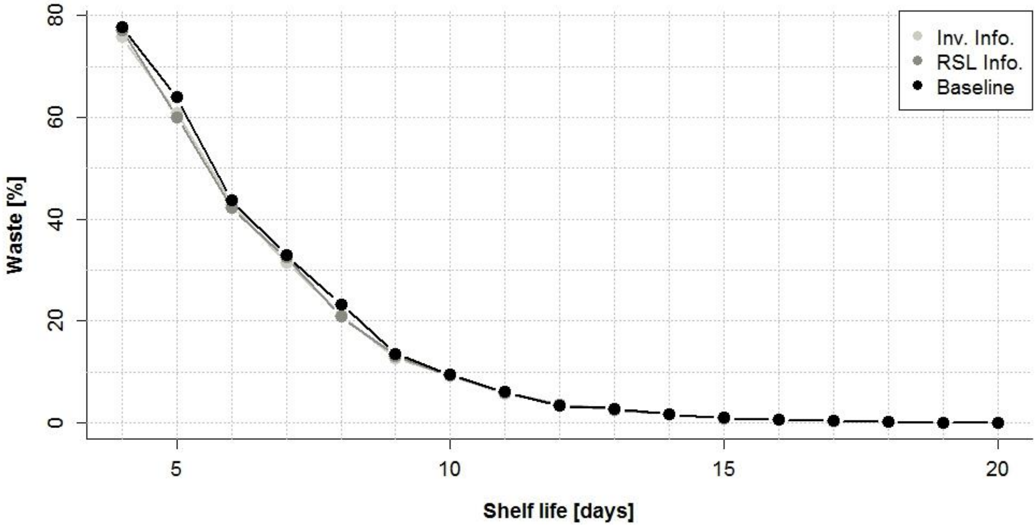

Figure 4.15: One year average waste across all stores and warehouse

In case of shortage, the two allocation policies will distribute the products more evenly across the requesting stores compared to a first-come-first-served principle (baseline scenario). Thus, if more stores should receive products (in case of shortage) more deliveries would also be required, which is coherent with Figure 4.16 illustrating a higher number of deliveries. As previously mentioned, this should not be understood as independent delivery of one product, merely that the truck going to the store (with other products) should include this additional product.

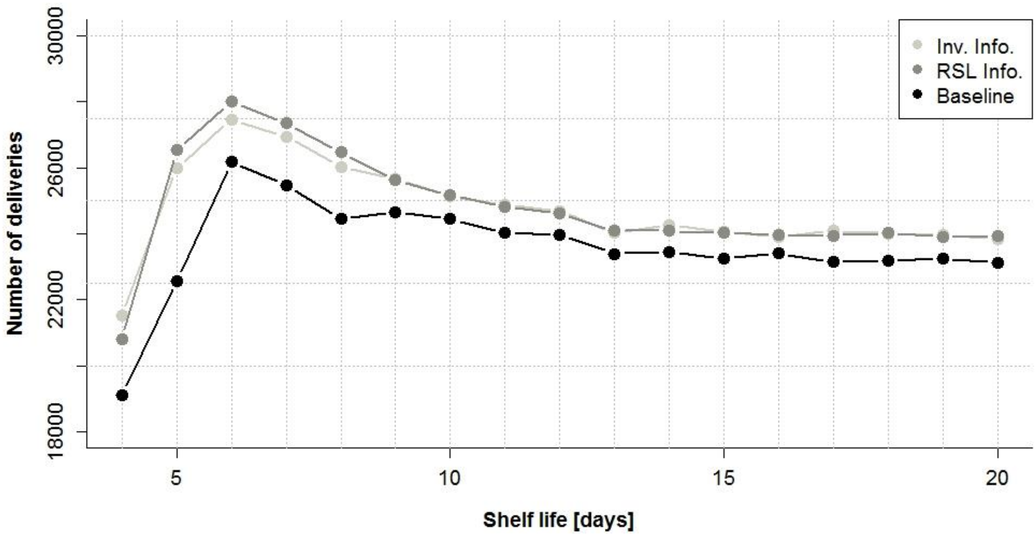

Figure 4.16: Total number of deliveries for one year for all stores and warehouse

On average (for products with a shelf life from 4 to 20 days) the allocation policy with access to inventory levels will use 4.8% more deliveries, while the second allocation policy with access to remaining shelf life information uses 5% more compared to the baseline. Compared to the similar improvement in fill rate and waste it could be argued that there will be no additional benefit of using remaining shelf life information compared to just using the information about the inventory level. However, using remaining shelf life information of inventory allocations makes a bigger dispersion (more deliveries) of the products. Accordingly, the benefits are also more equally shared among the stores. This can be exemplified using the coefficient of variation (standard deviation compared to the mean, CV), where a smaller CV indicates that all observations are closer to the mean observation. Or, in this case, where a smaller CV indicates that the performance improvement from the individual stores is closer to the mean performance improvement. The CV for the fill rate improvement is 0.35 if remaining shelf life information is used while using only inventory levels yields a CV of 0.41. Similar, with remaining shelf life information the CV is 0.68 for the waste reduction while using only inventory levels yields a CV of 0.73.

Inventory allocations distribute the available inventory in the system and as such will not influence the total amount of inventory within the system. However, as observed in Figure 4.17, both policies have a slightly lower average inventory level. Specifically, using inventory information for allocations reduces the average inventory level with 0.7%, while using remaining shelf life information reduces it with 1% (for products with a shelf life between 4 and 11 days compared to the baseline scenario). This small decrease in inventory is likely to be caused by the increased sales (higher fill rate) and lower waste, meaning that more products will leave the system faster and thereby increase the stock rotation. This also explains the very small average improvement of 0.3% in freshness (a figure for this is not included as it is too small to illustrate).

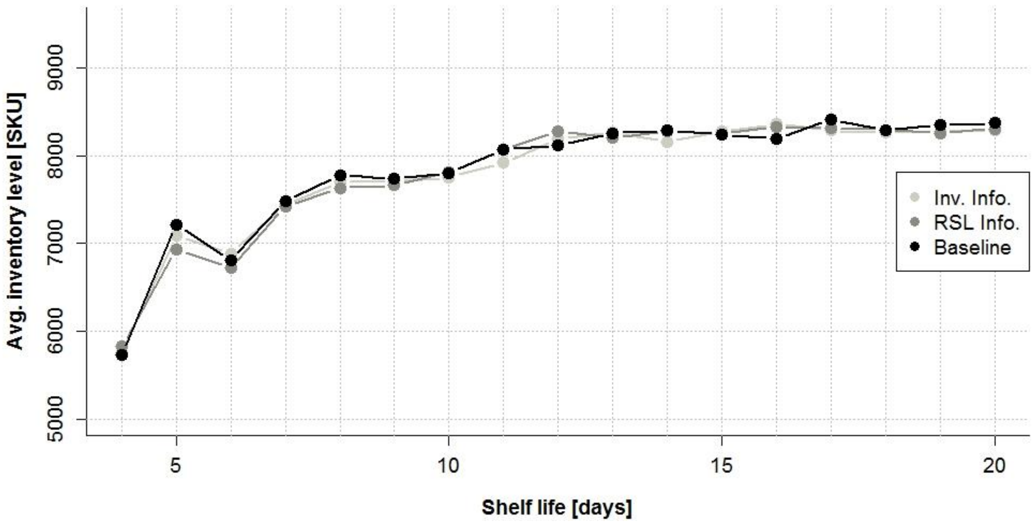

Figure 4.17: Average inventory level for one year for all stores and warehouse

On average the two policies would perform similarly in regards to improved waste (-3.8%) and fill rate (+3.3%). However, using remaining shelf information for allocation would result in more deliveries but in return also distribute the benefits more evenly across the stores. It should be noted that it is only possible to make different allocations when (1) the same product in the warehouse exists with multiple levels of remaining shelf life, (2) when there is a shortage at the warehouse, or (3) both (1) and (2) together. Combining the replenishment and allocation decision into one decision (requires central planning) might lift the performance even further.

4.4.3. Sensitivity analysis

Appendix E contains a sensitivity analysis where the batch size has been changed to 6 and 12 (compared to 9 which is used in Figure 4.14 to Figure 4.17). Similar to the sensitivity of the replenishment decision it is observed that as the batch size increase the number of deliveries decreases (more is delivered per trip), which in turn increases the average inventory level increase. A slight increase is observed in the fill rate as the batch decreases – this enables finer distribution among stores.

Most interestingly is the reduction in waste where a smaller batch size reduces waste by 3.9% with allocation based on inventory information and 3.2% with allocation based on remaining shelf life information. This indicates that the allocation based on remaining shelf life information is slightly more robust. However, combined these findings suggest that grocery retailers would benefit from applying one of these allocation policies together with a reduction in batch sizes.

4.5. Discussion

The previous section provides a terminology for shared information as well as estimates of the impact of utilizing shared information for improving decision making and thereby increase the alignment of supply and demand. The purpose of this section is to discuss these findings and make them more tangible and consolidating them into one entity. The section is divided into four subsections. Firstly, the practical implications of information sharing are discussed followed by a subsection which outlines how to benefit from differentiated information sharing in grocery retailing. The third subsection briefly comments on how the characteristics of the products influence the applicability of information sharing. The last subsection is devoted to highlighting the theoretical contributions that can be derived from the findings.

4.5.1. Implications

All findings indicate that utilizing shared information can improve the alignment of supply and demand. This is demonstrated by showing a simultaneous improvement in availability (lack of supply) on hand and reduced food waste (surplus of supply) on the other. However, a reduction of e.g. 1% point in food waste or 5% point increase in availability might be difficult to interpret and could sound rather insignificant, which questions the practical relevance of such findings. Accordingly, this section unfolds the practical relevance and implications of the findings.

Food waste at stores has both environmental and monetary implications. Environmentally, excess food consumes e.g. unnecessary transportation, energy, water, and cropland up through the supply chain, while the monetary implications is a direct loss of profit for the store. In 2014 the total profit of the three largest grocery retailers in Norway was 366 million Euro and a total turnover of 16,775 million Euro giving an average earning of 2.2%. Now, if 1.3% waste could be eliminated (this was the reduction identified in Section 4.2) this would potentially increase the average earnings to 3.5%. In other words, an increase in profit with another 218 million Euro to a total of 584 million Euro in profit. Thus, using shared information can have a significant monetary influence on grocery retailers.

The monetary impact of a stock-out (low availability) is not yet quantified in the literature (Aastrup and Kotzab, 2010). One could argue that a 95% availability would result in 5% of lost sales. However, consumers may switch to another brand, size, or color of the particular product and the store still generates its revenue. Similar, if the consumer switches to another store, but from the same grocery retailer, the revenue is still secured. Switching to a competing grocery retailer will, however, result in lost sales. These considerations are more short-term oriented. A continuous low availability level may negatively affect the loyalty of consumers and completely remove a potential revenue stream from the store. Even though the actual quantification of a low availability is difficult, it is still considered as one of the key performance measures for grocery retailing as it is an important part of the consumer experience (Aastrup and Kotzab, 2010). The findings from the previous sections demonstrated how shared information could contribute to improving this consumer experience.

Another implication for using shared information can be extracted from the findings. Shared information not only provides better transparency and enables better decision making – it can also enable an automatization of processes. This has several advantages. Firstly, if shared information is used to manage the inventory allocation, the warehouse can accurately identify the true requirement for each store. Hence, they can reduce the risk for shortage gaming (where customers incorrectly place a larger order than needed to receive the requested quantities), which is known to increase the bull-whip effect (Lee et al., 1997).

Secondly, if a process is automated the knowledge which is required to perform a given process is secured in an (IT) system and not dispersed around hundreds and hundreds of store employees with different levels of experience and expertise. Thus, it is easier for the store to cope with sickness and vacations while still making adequate replenishment decisions. Employment of new employees is likewise potentially going to be faster because only limited experience with ordering is necessary because the system can support the process. Additionally, employees in the store will have to spend less time on ordering, which can free up time for shelf replenishment, customer care, and other in-store activities.

Even though increasing the level of shared information can support employees and has shown to enhance several performance measures it also contains some possible risks which should not be neglected. Here, an important risk is information overload. Information overload may refer to "*having more relevant information than one can assimilate*" or "*being burdened with a large supply of unsolicited information, some of which may be relevant*" (Edmunds and Morris, 2000, p. 18). Endsley (2016) neatly illustrates this issues with the information gap concept depicted in Figure 4.18.

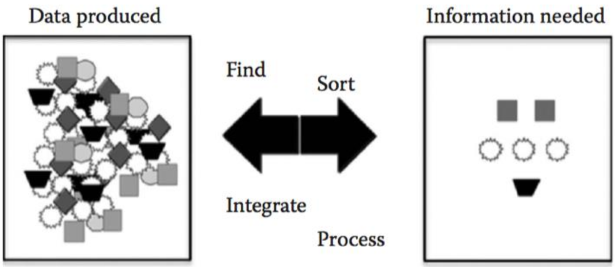

Figure 4.18: The information gap (Endsley, 2016)

The information utilization concept is a valuable remedy to reduce the risk of information overload. If some information is captured and shared it should be integrated into a process – otherwise there is a risk that the information may diminish transparency (because one is not able to adequately make use of it) instead of enhancing transparency. Compiling a map of the information flow (combined with the guidelines in Paper #4) in the supply chain can support grocery retailers with identifying where to use available information as well as identifying where to find relevant information – both contributing to close the information gap.

4.5.2. Differentiated Information Sharing

All findings, which estimated the potential impact of using shared information, highlighted how the shelf life of the product might moderate the impact. This is a useful insight for practitioners to differentiate the planning of their products and what information that should be shared. Firstly, based on the findings from the multiple case study depicted in Figure 4.4 (page 42) grocery retailers can obtain a reduction in food waste for products with a shelf life above 30 days – if they share and use waste and POS-information through an automatic replenishment system.

Secondly, for products with a shelf life below 20 days the findings from Figure 4.14 and Figure 4.15 (page 55-56) indicated an increased fill rate and reduced food waste if shared information (inventory levels or remaining shelf life information) where used for inventory allocations. Additionally, the findings from Section 4.3 depicted in Figure 4.13 (page 51) showed that sharing and utilizing remaining shelf life information for the replenishment decision could improve the performance (both fill rate and waste) of products with a shelf life up to approximately 11 days.

However, even though the findings in Figure 4.13 indicate that it is possible to obtain a high fill rate by automating the replenishment of perishable products with a shelf life down to 5-6 days the waste level might still be too high (above 50% in some instances). Thus, a more nuanced presentation of these findings is provided in Table 4.12 and Table 4.13 which shows the fill rate and waste for the baseline and EWA_{SS} scenario depending on the number of weekly deliveries the stores are allowed to receive. Using a specific example, a product with eight days of shelf life and two weekly deliveries has 78.8% fill rate and 42.6% waste with the baseline policy, compared to 94.3% fill rate and 37.5% waste with EWA_{SS}. The gray colors in Table 4.12 and Table 4.13 highlights the improved performance of the EWA_{SS} policy compared to the baseline. Specifically, the light gray indicates an improvement of 0.3% point or more, a medium gray indicates an improvement of 1% point or more, while the dark gray indicates an improvement of 3% point or more.

Table 4.12: Average fill rate for Baseline and EWA_{SS} depending on weekly allowed deliveries. Light gray: EWA_{SS} improves with 0.3% point or more, medium gray 1% point or more, dark gray 3% point or more

Weekly deliveries		Baseline				EWA_{SS}			
		6	5	3	2	6	5	3	2
Shelf life [days]	**4**	48,9	44,7	36,1	27,6	67,0	68,0	54,4	36,7
	5	69,9	62,1	54,1	44,8	80,9	76,6	70,0	58,5
	6	82,4	80,8	72,7	53,7	91,1	90,0	86,3	72,7
	7	85,9	85,6	81,2	70,3	90,4	92,9	92,2	91,7
	8	92,0	91,2	86,6	78,8	92,9	93,8	92,9	94,3
	9	94,0	95,2	92,6	86,5	95,0	96,3	95,4	93,3
	10	95,6	95,8	94,3	91,0	95,6	95,6	95,6	94,3
	11	95,6	96,5	95,6	93,7	95,9	96,7	96,7	96,2
	12	95,7	97,1	97,2	96,4	96,0	97,2	97,1	97,4
	13	96,2	96,8	96,6	94,6	95,8	97,2	97,3	96,8
	14	95,8	97,1	97,7	96,8	96,9	97,3	97,4	97,3
	15	95,8	97,3	97,1	97,1	95,2	97,1	97,6	97,9
	16	95,8	97,3	97,7	97,6	96,0	97,2	97,7	97,6
	17	95,5	96,7	97,5	97,5	96,0	97,2	97,4	97,9
	18	95,7	97,2	97,6	98,0	95,3	97,2	98,0	98,1
	19	95,2	97,2	97,8	98,3	95,4	96,9	97,6	98,1
	20	95,9	97,1	97,5	98,0	95,1	97,1	97,7	98,1

Table 4.13: Average waste for Baseline and EWA_{SS} depending on weekly allowed deliveries. Light gray: EWA_{SS} improves with 0.3% point or more, medium gray 1% point or more, dark gray 3% point or more

		Baseline				EWA_{SS}			
		6	5	3	2	6	5	3	2
Shelf life [days]	**4**	51,4	59,3	70,1	76,6	47,5	52,4	65,8	78,2
	5	34,3	49,5	60,1	70,0	34,8	45,6	56,4	67,4
	6	29,3	35,2	46,0	62,9	24,3	31,3	41,6	58,1
	7	19,2	25,7	36,3	50,4	16,5	21,7	31,6	44,7
	8	11,2	15,6	26,4	42,6	7,1	14,4	23,4	37,5
	9	3,8	8,1	16,5	29,7	3,3	8,3	15,9	27,5
	10	2,0	5,3	11,5	23,8	1,4	5,6	11,9	23,3
	11	1,0	2,9	7,5	17,4	0,8	3,1	7,5	16,6
	12	0,4	1,2	4,4	11,8	0,2	1,2	4,4	11,7
	13	0,0	0,9	3,7	10,9	0,1	0,8	3,7	10,4
	14	0,3	0,2	1,5	7,6	0,0	0,4	1,8	7,1
	15	0,0	0,2	1,7	4,7	0,0	0,2	1,5	4,7
	16	0,1	0,1	0,7	3,2	0,0	0,1	0,9	3,0
	17	0,1	0,1	0,4	2,1	0,0	0,0	0,7	1,9
	18	0,0	0,0	0,3	1,3	0,0	0,0	0,3	1,2
	19	0,0	0,0	0,3	0,6	0,0	0,0	0,2	0,7
	20	0,0	0,0	0,3	0,7	0,0	0,0	0,2	0,7

From an information sharing and inventory policy perspective, the interesting question is when the two alternatives overlap and when it is no longer beneficial to share remaining shelf life information and use the EWA_{SS} policy. This overlap is of interest because the EWA_{SS} policy requires additional information to be captured, which may necessitate an investment from the grocery retailer. An example of this "crossing point" is products with a shelf life of 12 days and 3 weekly deliveries. Here both the baseline and the EWA_{SS} policy provides a 4.4% waste and the fill rate is 97.1% and 97.2%. For products with a lower shelf life, it would be beneficial to use the EWA_{SS} policy, while products with a longer shelf life would get the same results by using the either the EWA_{SS} or baseline (few excepts where the EWA_{SS} policy is better).

Based on Table 4.12 and Table 4.13 from above Figure 4.19 aims to illustrate this "crossing point". Specifically, Figure 4.19 shows two aspects. Firstly, the two gray areas indicate what information to share and what policy to apply based on the shelf life and the delivery frequency. For example, for stores with three weekly deliveries, it would be beneficial to share remaining shelf life information and use the EWA_{SS} policy for products with a shelf life between 7 and 11 days. In both gray areas, the fill rate is 90% or higher, which is considered reasonable for perishables products (Breokmeulen and van Donselaar, 2009). However, in the dark gray area, the EWA_{SS} policy provides a higher fill rate and/or a lower waste (except products with a shelf life of 9 days and five weekly deliveries where the baseline has a 0.2% lower waste) compared to the baseline policy. In the light gray area, the two policies perform (almost) equally compared to waste and fill rate.

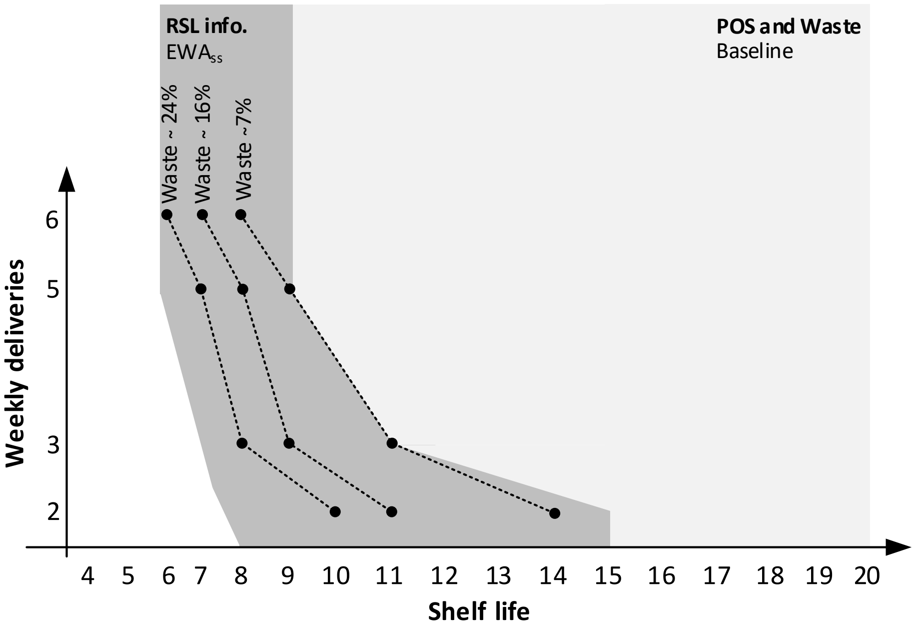

Figure 4.19: General guidelines for what information to share and which inventory policy to apply to achieve at least a 90% fill rate depending on the delivery frequency and the product's shelf life

The second aspect that is illustrated in Figure 4.19 is the dotted lines. They depict the approximate waste levels depending on the delivery frequency and the shelf life. For example, for products with 11 days of shelf life in stores with 3 weekly deliveries approximately 7% waste would be expected (specifically 7.5% as seen from Table 4.13). The same 7% waste level would be expected for products with 8 days of shelf life and 6 weekly deliveries (specifically 7.1% as seen from Table 4.13).

On the left side of the dark gray area, none of the results from the simulation study indicated a satisfactory performance in regards to fill rate (too low) and waste (too high), and these products are likely subject to be handled manually. Based on the sensitivity analysis it might be possible to use the EWA_{SS} in some parts of this area if the batch size is reduced simultaneously.

An interesting observation from Figure 4.19 is that the dark gray area increases (in the shelf life range) as the weekly number of deliveries decreases. This indicates that sharing remaining shelf life information and using the EWA_{SS} policy has the biggest applicability for smaller stores with 2 to 3 weekly delivers.

For comparison, in the multiple case study (see Figure 4.4, page 42) all products were delivered three times per week and a product with a shelf life of 20 days was recorded to across the different stores have a waste level between 0.6% and 20.5% (average of 6%). Based on the simulation products with 12 days of shelf life and three weekly deliveries has on average 4.4% waste, and products with 20 days of shelf life have 0.3% waste. Even though it is not completely equal, it is still considered comparable and adds to the validity of the simulation model. The waste levels are naturally lower in the simulation model because not all uncertainties can be included. For example, products that are wasted due to transport damages or consumers which may drop the products are not part of the simulation model but included in the multiple case study. Likewise, in the multiple case study consumers may choose not to buy a specific product because of its appearance (wrinkled apple, grayish meat, etc.) even though it is not expired. This will increase the waste level in the multiple case study, and this aspect is not included in the simulation model and adds to the discrepancies between to two studies.

4.5.3. Influence of Product Characteristics on Information Sharing

A part of the information utilization concept was that information needs to be captured before it can be shared and utilized. Thus, it is important that the characteristics of the product – especially the packaging – makes such data capturing possible. With this, it is also possible to evaluate which products that are adequate for either replenishment or inventory allocations based on shared information. Firstly, the products should be sold individually between the warehouse and the store to keep an accurate estimate of the inventory level. Meaning, products sold in bulk such as cases of apples or bananas are not preferable. These types of products are often sold by weight to the stores (e.g. 20 kg. of bananas) but sold per item to the consumers, which makes it difficult capture the inventory level at the stores. If the products are sold by weight to the consumers, it might be possible. However, it should be carefully considered if 20 kg of bananas have the same weight three days later or if they evaporate and “loses weight”.

A second aspect to consider is mainly in regards to when remaining shelf life information should be shared. The EWA_{SS} (and EWA) policy assumes a predetermined shelf life. Thus, e.g. packed tomatoes without a predetermined expiration date is not applicable (this might be estimated based on time and temperature log (Ketzenberg et al., 2015)). Ideal products are dairy, meat, prepacked cold cuts, special types of cheese, and fruit and vegetables with an expiration date. Among these products, it should be considered how easily the remaining shelf life information can be captured. Radio-frequency-identification (RFID) chips per item is a possible but maybe expensive solution.

An alternative could be to include the shelf life information in an extended barcode or detect the expiration date by video cameras placed close to the shelf.

4.5.4. Theoretical Contributions

The findings related to research question 1 adds to the theoretical understanding of information sharing and particularly for information sharing in grocery retailing. As a starting point, four facets (content, timeliness, source, and modality) and its underlying elements were identified in order to characterize information sharing. These facets were used to develop the information utilization concept proposed by Jonsson and Myrelid (2016). Specifically, it was emphasized how shared information should be linked to various planning decisions, and a refined definition of information utilization was proposed to encapsulate this aspect. Opposite to Jonsson and Myrelid (2016), the definition makes a clear distinction between information sharing and information utilization, which is necessary as the same shared information can be utilized for different purposes.

To identify the need and possibility of using shared information a mapping notation for information flow was developed. The notation includes the four facets (and underlying elements), illustrates where information is captured, where it is utilized, and highlights areas for improvement. The notation builds on the ideas from Verdouw et al. (2010) by adding the information flow as an additional layer to the existing notation from the SCOR model. Hence, a more comprehensive representation of decision processes as well as material and information flow can be established.

Having established a terminology to comprehensively represent information sharing, three main studies were conducted to evaluate the impact of different levels of information sharing and information utilization. Firstly, the impact of utilizing shared POS and waste information for more sustainable (less food waste) grocery retailing has been empirically investigated, and it adds to this limited amount of literature on this topic (Kaipia et al., 2013). The findings showed an improvement in both reduced food waste and improved freshness at the stores without harming availability. This supports proposition 1b by Mena et al. (2014) claiming that improved transparency can reduce supply chain wide food waste.

The second study evaluated the impact of sharing remaining shelf life information because it is often discussed as a means to automate replenishment of perishables (Van Donselaar et al., 2006). Through simulation studies, the impact of utilizing this information with the EWA policy in a more realistic supply chain (200+ stores, actual demand data, combined FIFO and LIFO depletion) has been evaluated and adds to this body of knowledge (Broekmeulen and van Donselaar, 2009; Duan and Liao, 2013; Lowalekar and Ravichandran, 2015). Specifically, it was shown that the EWA policy provides a high availability for perishables but in return suffers from high inventory level and only slightly reduces waste for products with a shelf life below approximately 11 days if it is applied in a divergent supply chain.

To offset the high inventory levels obtained with the EWA policy and reduce waste levels further the EWA_{SS} was proposed and evaluated. It builds on the work by Broekmeulen and van Donselaar (2009) and Van Donselaar and Broekmeulen (2012) and provides a more pragmatic solution to setting safety stock levels. The EWA_{SS} policy uses the same shared information as the EWA policy. For products with a shelf life less than 11 days the EWA policy outperforms the EWA_{SS} policy in regards to availability while the EWA_{SS} policy provides a lower waste level in the same range. However, the EWA_{SS} policy provides a more balanced performance of food waste and availability across all shelf lives compared to EWA and a traditional automatic replenishment system – which is in line with the objective of this thesis. Additionally, the EWA_{SS} policy was able to obtain these performance gains with a small decrease in the average inventory level.

The third study used the inventory and remaining shelf life information intended for replenishment for inventory allocation decisions. This exemplifies how the same information can have another potential utilization for different decision processes (another information utilization). Two different inventory allocation policies were proposed and evaluated adding to this limited body of literature (Karaesmen et al., 2011). The findings indicate that even though the potentials are small in magnitude, it is still possible to allocate products more evenly across the supply chain to align supply and demand. Also, the findings indicate that a big part of the potential can be reaped just by using inventory level information (the same information as for traditional automatic replenishment systems).

Both the empirical study and the simulation studies suggested that the impact of using shared information is dependent on the shelf life of the product, which is only peripherally mentioned but not explicitly studied in the literature (Kembro, 2012). It was discussed how the shelf life of the products (and the delivery frequency) could be used as a guideline for what information to share and which inventory policy to use. This emphasizes the criticality of the shelf life characteristic when planning in grocery retailing.

Overall, the findings support previous literature (e.g. Kaipia et al. (2013)) and indicate the impact of utilizing shared information for planning in grocery retailing. The findings suggest that by utilizing the increased transparency provided by information sharing is it possible to improve the alignment of supply and demand. The actual size of the improvement depends (at least) on the type of shared information, the type of decision, how it is utilized, the shelf life of the product, the delivery frequency, and the performance measured used. In this PhD study, the impact of information sharing was empirically quantified to be 17.8% (1.3% point) lower food waste and 5.2% increased freshness across all shelf lives. Through simulation studies of the replenishment decision, an average of 10-17% increase in fill rate and 3-10% reduction in food waste was observed (depending on the policy used) for products with a shelf life below 11 days. Additionally, the simulations of the proposed inventory allocations revealed an additional 3.3% improvement in fill rate and 3.8% reduction in food waste.

Aligning Supply and Stimulated Demand 5

During the data collection and analysis of the automatic replenishment system in one of Norway's largest grocery retailer, it became clear that demand-stimulated activities such as promotions and product introductions were managed outside of the automatic replenishment system. Specifically, a separate portal was available for stores to order products on promotions. Mainly because these created an abnormal sales pattern and more human attention was needed. However, it was at that point also stated that managing these activities was difficult, and it was perceived to contain a room for improvement. Because of the importance, of especially promotions (see. Figure 1.2, page 3 and Figure 2.5, page 20), for grocery retailing it was decided to slightly expand the scope and examine this area further. Thus, as a subordinate topic of this thesis this chapter present and discusses the findings related to research question 2: "How do grocery retailers effectively align supply and stimulated demand?". Referring to Figure 2.1 (page 9) and Figure 2.2 (page 10) the focus is moved from the operational planning level to the tactical planning level as this level covers stimulated-demand activities.

The chapter contains two main sections, with the first presenting the findings and the second discussing the implications and identifying possible connections to information sharing from the previous chapter and an outlining of the theoretical contributions.

5.1. Enhancing Tactical Planning in Grocery Retailing

To compile an overview of tactical planning and understand the challenges faced in this process the tactical planning process at the Norwegian grocery retailer was mapped and investigated. This explorative study (see Paper #6) resulted in a process as depicted in Figure 5.1.

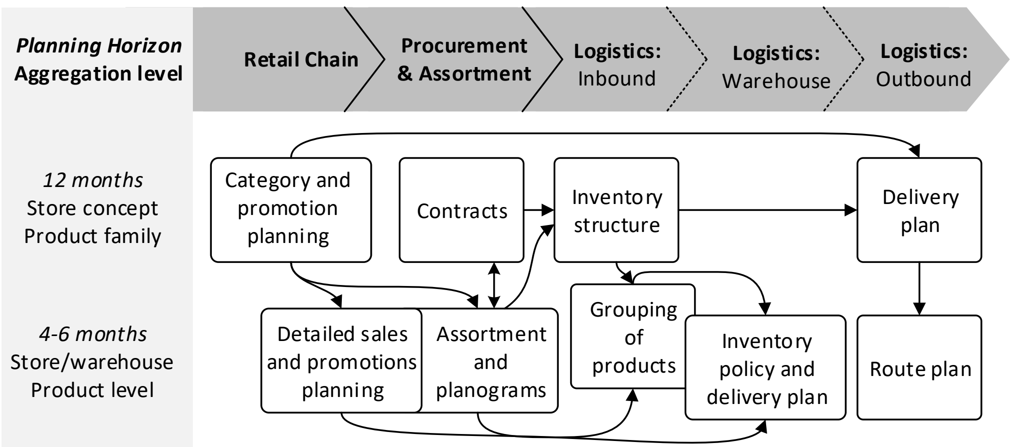

Figure 5.1: Tactical planning process at a Norwegian grocery retailer

Figure 5.1 shows the tactical planning for all products (not only those related to stimulated demand). The process starts in the upper left corner where the 'retail chain' decides the main profile of the chain concept and the product categories and promotions for each concept. This plan is afterward disaggregated into specific products, volumes and time periods for the promotions. The 'procurement and assortment' function finalizes the master category plan, adjusts planograms, and matches specific products with suppliers to establish contracts. The contracts regulate the conditions for the purchase and deliveries (price and discounts, volume, frequency, promotions, packaging size) for a 12-month period, while the planograms for each store or store concept are updated every 4 months. Based on the volumes specified in the contracts and the expected sales in each geographical area, the inventory structure is decided (small adjustments might be made during the year). Hereafter, all products are divided into different logistical product groups before the inventory policy and delivery plan is finalized. The inventory and delivery plan specifies when and how much to collect from each supplier. Lastly, the plan for outbound deliveries from warehouse to stores is made on two hierarchical levels. Based on the profile of each concept, the store revenue, and the inventory structure guidelines are provided for the number of weekly deliveries for three high-level product groups: a) frozen/dry/fresh food, b) fruits and vegetables and c) products from the central warehouse. Large stores get more frequent deliveries than smaller stores. Finally, the individual routes from the warehouse to the stores are calculated by balancing the delivery plan with the utilization of each truck.

Two main findings were made during the explorative study. Firstly, as indicated by Hübner et al. (2013) tactical planning in retailing occur at two levels with a long (12 months) and medium (4-6 months) time horizon. The upper tactical planning level determines the overall arrangement of the category, number of promotions, contract formulation, inventory structure (where should goods be stored), and an aggregated delivery plan. The lower tactical planning level then makes more detailed decisions within these boundaries (what products should be included in the promotion, how should the planograms be adjusted to account for new products, etc.).

Secondly, and more interestingly, the process suffers from limited cross-functional coordination and feedback. As indicated by the arrows most of the decisions are sequential and top-down oriented. For demand-stimulated activities, this means that little attention is paid to the effectiveness of previous demand-stimulated activities, and it may be difficult to adequately respond to rapid changes in the market because tactical decisions are not jointly coordinated and implemented among functions. Likewise, there is limited coordination of sub plans. For example, product introductions may not be entirely coordinated with future promotions and cannibalization (or amplifying) demand effects might end up being unnoticed.

To support grocery retailers in tactical planning and especially on the lower tactical planning level where demand-stimulating activities play a major role, a multiple case study involving four case companies was conducted to gain more insight and eventually increase the generalizability of the findings. The four case companies were two Norwegian grocery retailers, one British grocery retailer, and a Finnish wholesaler that serves four grocery retailers. Paper #7 includes an elaboration for why these companies were selected as well as a detailed analysis of each company.

From the case companies, it became clear that the lower tactical planning level consisted of promotions planning, product introductions, and seasonal planning. All activities that aim to stimulate demand. As observed in the first case, even though all three activities were conducted with (almost) the same planning horizon and by similar functions, the three plans and functions were not always coordinated. The four cases were examined through the lens of S&OP and how S&OP could enhance the tactical planning process in grocery retailing. S&OP was selected as the theoretical lens due to its focus on mid-term planning horizon and because S&OP has a well-established process which seeks to balance supply and demand by involving all major functions. Hence, it was expected that S&OP could improve integration of both sub plans and among functions.

Based on the four cases and the reviewed literature six propositions, including a S&OP process, were proposed (see Paper #7) in order to integrate plans and functions and hereby manage the demand-stimulating activities for grocery retailing. The first proposition emphasizes this general need to combine the different plans and functions, which is proposed to be managed through an adapted S&OP process as depicted in Figure 5.2.

> <u>Proposition 1:</u> *Because of the nature of demand management in grocery retailing, particularly seasonality, promotions, and frequent product introductions, tactical planning would benefit from adopting a more formal planning process, integrating functions and sub-plans into a single plan with shared planning objectives.*

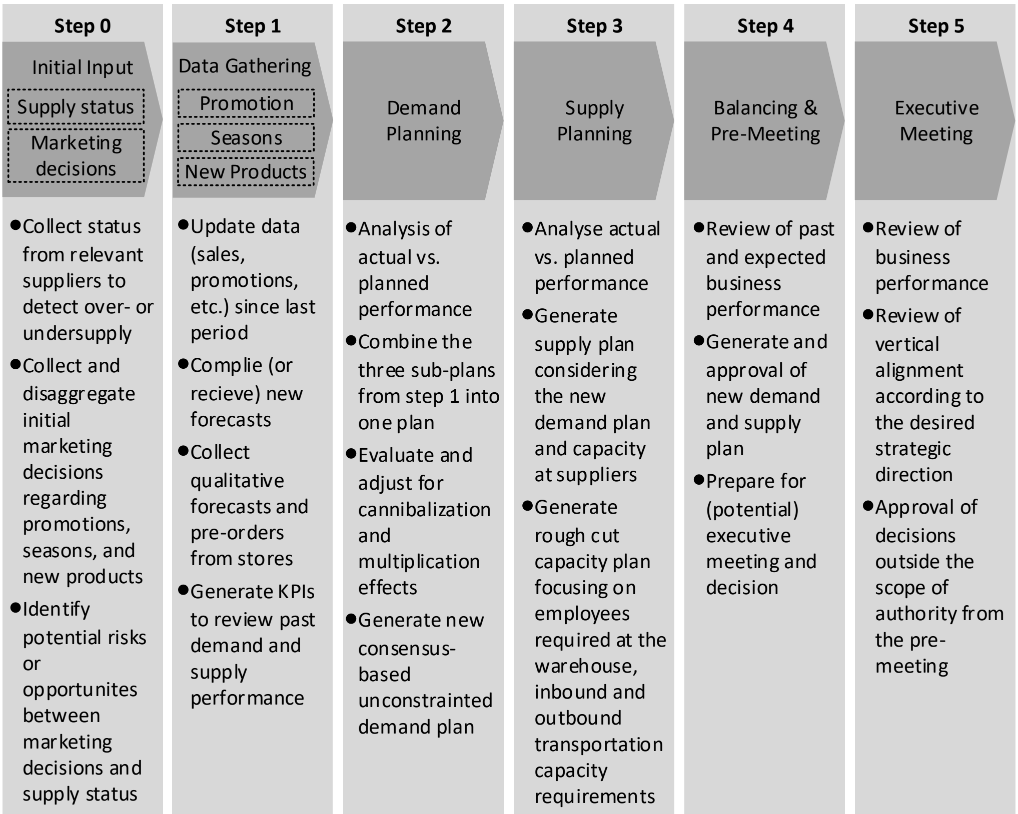

Figure 5.2: Proposed S&OP process for grocery retailing

Opposed to the S&OP process proposed by Yurt et al. (2010) (see Figure 2.8, page 24) it was observed that "initial supply planning" was the very first activity in all four cases. Also, it did not only consist of supply planning but also entailed initial input for promotions and seasonal planning. Thus, in Figure 5.2 it is rephrased to "initial input" and placed as Step 0. Aggregated market decisions regarding sales, promotion, and similar demand stimulated events are collected and compared to the status at the suppliers. Step 1 can in principle run as three parallel and separate processes for promotions, product introductions, and seasonal planning as the idea of step 2 is to combine the three plans into one consensus-based unconstraint demand plan. Step 3 is the generation of the supply plan, where capacity at suppliers is considered, as well as the inbound and outbound transportation capacity. At Step 4 the demand and supply plans are approved together with a review of performance. In case of disagreement or need for radical decisions, an executive meeting should take place as the last step.

The adapted S&OP process should have a time horizon that covers the next sales season, as this was generally found to be the longest time horizon compared to product introductions and promotions. The planning frequency is monthly but should be adjusted if opportunities or risks arise from the supply side (e.g. due to availability problems) or at the demand side (e.g. due to competitors actions, new stores, etc.). Since the focus on demand-stimulating activities is so high, the S&OP process can be conducted on an SKU-level, as also reflected in all four cases and have been previously reported as the norm in the food and grocery retail industry (Holmström *et al.*, 2002; Ivert *et al.*, 2015).

The following five propositions aim to support the S&OP process and increase the awareness for this type of planning in grocery retailing. Particularly, form the cases it was observed that planning in grocery retailing centers around operational decisions and the limited focus (from executives and managers) to tactical decisions is mostly to boost sales with vague considerations to the rest of the supply chain. Thus, to successfully implement a S&OP process grocery retailer would require more managerial support than currently found. Or, in other words:

> <u>Proposition 2:</u> *Grocery retailers' planning-related culture and leadership should facilitate and enhance formal collaborative planning and foster a supply chain perspective to the planning. This includes support and ownership from top management, shared objectives for planning, rewards, and empowerment.*

It was observed that even at a low level of internal integration (between functions) some case companies managed to integrate with either suppliers or customers in their tactical planning. E.g., the purchasing department in the Finnish wholesaler conducted monthly meetings with their customers to assess forecast accuracy and jointly approve the forecast for the coming period. Yet, they did not manage to coordinate transportation or warehouse requirements with the internal logistics department. Clearly, if grocery retailers want to succeed with a S&OP process internal integration would be required. This should be facilitated by a proper organizational structure:

> <u>Proposition 3:</u> *Grocery retailers would benefit from an organizational structure with dedicated responsibility to integrate functional decisions from category and assortment, purchasing, and logistics to reach a single consensus-based tactical supply and demand plan.*

The inclusion of suppliers and customers was in some of the cases mostly observed by a passive input of availability confirmation from suppliers or using POS information from stores. External integration should be pursued simultaneously with internal integration to obtain a supply chain-wide understanding of constraints and opportunities for stimulated demand activities. This is important both during the "initial input" in step 0 but also later when balancing supply and demand. Therefore:

> Proposition 4: *Grocery retailers would benefit from a supply-chain wide planning perspective, which actively seeks to involve suppliers and customers into their tactical planning process to adequately understand demand, create demand, and ensure availability of products.*

It was found that planning for stimulated demand activities is handled on SKU-level in grocery retailing and not on family-level as traditional S&OP planning. This detailed level is needed to account for e.g. cannibalization of non-promotional products and ensuring availability at suppliers of exact products. Consequently, to operate on this level of detail, the planning horizon was correspondingly observed to be shorter than in traditional S&OP. To support the planning on a SKU-level it was observed that a single IT system (compared to fragmented) was valuable to increase the efficiency of the planning process and communicate decisions. However, one of the Norwegian grocery retailers, which managed to integrate decisions across functions did so with the use of six different IT systems. This, somehow rather contradictory, observation is reflected in the fifth proposition:

> Proposition 5: *A single integrated IT solution may contribute to the efficiency and communication of the tactical planning process in grocery retailing due to detailed planning on SKU-level, but does not ensure integration without changes in planning orientation.*

Lastly, as observed in the initial explorative study (Paper #6) nearly all of the cases in the multiple case study (Paper #7) had no formal feedback loop for the planning of stimulated-demand activities. Not knowing – and reflecting – on previous performance principally means that the process starts from scratch each time. However, some tacit knowledge and experiences might obviously exist for the individual employees. The limited feedback might be caused by the use of mostly operational measures such as forecast accuracy and inventory levels, which might not necessarily mirror the performance of the demand-stimulated activities. Grocery retailers should apply performance measures that reflect how well the demand-stimulated activities was realized and which will require cross-functional teamwork to succeed. An example is from the British grocery retailer that evaluated the effectiveness of promotions and shrinkage in other products groups. Effective promotions would, among others, require proper pricing decisions (marketing department) as well as an outstanding balance of supply and demand (purchasing and logistics department). It is proposed that:

> Proposition 6: *Grocery retailers would benefit from a cross-functional and process-level planning performance evaluation which should be used as an input for the next planning round to gradually improve knowledge on demand stimulating activities.*

5.2. Discussion

The previous section proposed initiatives for how grocery retailers could enhance its tactical planning process to align supply and stimulated demand. The purpose of this section to relate the most relevant propositions to the findings of information sharing to identify possible connections between the two. Particularly proposition 4 about external involvement is discussed in the first subsection, and proposition 6 about performance assessment is discussed in the second subsection. Additionally, the last subsection is dedicated to highlight the theoretical contributions.

5.2.1. Utilizing Shared Information for Planning Stimulated Demand Activities

Referring to Chapter 4 and the challenges related to tactical planning it appears fruitful to discuss if shared information could contribute to the alignment of supply and stimulated demand. In all four case studies, the grocery retailers (or wholesaler) used downstream information, such as POS-information or pre-orders, to establish the first forecast for promotions, product introductions or seasonal peaks. The (reduced) price might already be included in the POS-information. However, grocery retailers should aim to identify and capture information (as pinpointed in the information utilization concept) that influences the magnitude of the demand in their stimulated demand activities. This also includes non-transactional information, such as placement of products in the stores, marketing material, and similar product on promotions at the same time (either by the same grocery retailer or at a competing grocery retailer).

If this type of information is captured and shared it can be a valuable input for generating a forecast. To make it quantifiable (and include it in statistical forecasts) the grocery retailers might choose to create different scales. For example, placing the products right at the front door is considered a 5 on the "locational-scale", while simply keeping promoted products in their regular space is rated 1. Similar scales could be made for marketing materials and competing products. Table 5.1 summaries the facets of the shared information that could be captured and how to utilize it. As shown in the table, because these types of decisions are tactical (and not day to day decision) the frequency and aggregation of the shared information might be weekly instead of daily as for replenishment decisions.

Table 5.1: Sharing and utilizing additional information for demand stimulated activities

Facets and elements of shared information			Information utilization
Content	*Type*	Placement of products, marketing material, similar products on promotions	• Quantify (e.g. 1 to 5) the scale of each piece of information. • Include as an independent variable for statistical forecasts
	Aggregation	Weekly, SKU, store level	
Timeliness	*Frequency*	Weekly	
Source		Store	
Modality		EDI or electronically	

Another initiative for utilizing information sharing is specifically related to product introductions. In a recent study by Kaipia et al. (2017), it was shown how increasing the frequency, and finer aggregation of shared POS-information could benefit suppliers. The study showed that with access to frequent updates of daily sales figures from the stores (instead of aggregated into weekly buckets) the supplier was able to make a simple graphical representation of the sales each day. This enabled the supplier to more precisely observe when new products have reached a steady-state (stagnation) or if the sales continued to increase above the expected steady-state level. With this insight, the supplier could adjust production accordingly.

5.2.2. Utilizing Shared Information to Assess Stimulated Demand Activities

As outlined together with proposition 6 grocery retailers should assess the impact of their demand stimulating activities. The two performance measures from the British grocery retailer, namely, the effectiveness of promotions and shrinkage (or growth) in product groups, are such assessment measures and would obviously require the grocery retailer to analyze shared POS-information. This includes assessing if the product on promotion reached the expected sales level, and how the promotion affected sales in other product groups. If the performance deviates from the what was expected additional information might provide insights into the cause. E.g., the supplier was not able to deliver as intended (and why), the transportation was delayed on the road, the warehouse had a stock-out, etc. This information is then included in the next planning round to ensure a continuous improvement.

An important measure of the effectiveness of demand stimulated activities might not only be increased sales of a particular product but more generally, if it *actually* stimulates consumers and increases footfall in the store. As presented in the introduction, a 1.2% year-to-year decrease in footfall is expected for physical grocery stores (Richardson, 2016), and it should be carefully considered if the demand stimulated activities indeed improves footfall as intended (Dani, 2015; Vend, 2016). Capturing the footfall in the stores and sharing it with the grocery retailer's S&OP team would be a first step to complete this assessment.

5.2.3. Theoretical Contributions

Paper #6 and #7 is positioned within the limited literature of tactical planning in grocery retailing (Kuhn and Sternbeck, 2013). The propositions and the proposed S&OP process for grocery retailing build on the previous work that has identified and systemized planning in grocery retail (Hübner et al., 2013; Yurt et al., 2010). This contribution further adds to the understanding of how S&OP planning can be applied in other industries than where it was originally intended (Thomé et al., 2014). E.g., the proposed S&OP process shows how the characteristics of the industry, such as supply uncertainty, is incorporated by the additional step 0 of "initial input".

The findings also support some findings from previous research. Specifically, for food producers, it was overserved S&OP planning typical is managed on a SKU level with a time horizon covering 4 to 15 months (Ivert et al., 2015; Yurt et al., 2010). This was also observed in the tactical planning process for grocery retailers, indicating that they obey their mantra – "retail is detail" (Hübner et al., 2013). It appears that by reducing the time horizon, the grocery retailers can do this detailed planning which is necessary for their decision-making.

Conclusion 6

The purpose of this chapter is to condense the work and considerations underlying the previous chapters. The first section offers an answer to each of the listed research questions identified from practical challenges and gap in literature. Afterwards, a section is devoted to discuss the limitations of the studies and proposals for future research.

6.1. Revisiting the Research Questions

The objective of this PhD research was to contribute to how grocery retailers can align supply and demand through improved decision making in their planning processes. This objective has been examined by (1) considering the use of information sharing, and (2) explorative studies for stimulated demand. In the following an explicit answer to each research question is provided as well as a brief outline of the theoretical contributions that were extracted from the findings. The answer for research question 1 is assembled based on the two sub-questions 1a and 1b.

Research Question 1: How does information sharing contribute to align supply and demand in grocery retailing?

The findings of this PhD indicate that information sharing can increase the transparency of the supply chain, i.e. that the receiving entity of the shared information more clearly understands the previous, current, or future situation at the sending entity. Depending on the facets of the shared information the receiving entity can utilize the information to make more precise planning decisions and thereby improve the alignment of supply and demand. In grocery retailing, the magnitude of the improvement depends (at least) on the type of shared information, the type of decision, how it is utilized, the shelf life of the product, the delivery frequency, and the performance measured used.

Research Question 1a: How is information sharing characterized in grocery retailing?

The conducted research contains the identification of four facets (content, timeliness, source, and modality) with underlying elements to characterize shared information. These have supported the development of a mapping notation to comprehensively depict information flows, as well as contributing to a refined understanding of information utilization. Combined, this can provide practitioners and academics with a more holistic and encompassing understanding and support the journey of planning with shared information.

Research Question 1b: What is the impact of information sharing in grocery retailing?

Shared information should be linked and utilized in planning decisions. As part of this research, a multiple case study of an automatic replenishment system has been conducted, where the automatic replenishment system is managed by the warehouse and utilizes shared point-of-sales and waste information from the stores to calculate the replenishment quantity to each store. The findings indicated that automatic replenishment, across 54 products, on average reduced food waste with 17.8%, and with a supporting analysis of 4 products a 5.2% improvement in freshness was observed.

The multiple case study also indicated that for products with a shelf life below 30 days additional information might be necessary to obtain adequate replenishment quantities in automatic replenishment systems. Subsequently, a new age-based replenishment policy, EWA_{SS}, has been developed which utilized remaining shelf life from stores to calculate replenishment quantities. For products with a shelf life between 4 to 11 days a discrete event simulation model with 232 stores demonstrated that the EWA_{SS} policy was able to, on average, improve availability with 10.3% and reduce waste with 10.7% while slightly decreasing the average inventory level with 0.3%.

In a similar vein, two inventory allocation policies have been developed which utilized inventory information from stores or remaining shelf life information from stores. This information is utilized to make age and volume allocation from the warehouse to the stores. Through the same simulation model a 3.3% increase in availability and 3.8% reduction in waste was identified for products with a shelf life between 4 and 11 days.

In short, the theoretical contributions of these findings can be summarized:

- Advancement of the information utilization concept (Jonsson and Myrelid, 2016)
- An empirical evaluation of information sharing from a food waste perspective (Mena et al., 2014; Kaipia et al., 2013)
- A new age-based replenishment policy, EWA_{SS} (Broekmulen and Van donselaar 2009)
- Two inventory allocations policies for perishables (Karaesmen et al., 2011)
- An assessment of the policies subject to the shelf life of the product (Kembro, 2012).

To consolidate the findings, general guidelines for when to share more advanced information (remaining shelf life) and how to utilize it in regards to replenishment policies have been proposed. The EWA_{SS} policy contributes to the alignment of supply and demand and can enable automatic replenishment systems to function for perishable products with a shelf life down to 6-8 days depending on the delivery frequency. Specifically, for stores with two weekly deliveries, it is indicated that it will be beneficial to use the EWA_{SS} policy for products with a shelf life between 8 to 15 days, whereas a store with six weekly deliveries might find it beneficial for products with a shelf life between 6 to 9 days.

For inventory allocations, the use of remaining shelf life information provides a more even distribution of the benefits across stores. However, average improvements are possible to achieve with the information already embedded in a traditional automatic replenishment system, which means no additional investment in data collection is needed.

Research Question 2: How do grocery retailers effectively align supply and stimulated demand?

The tactical planning level was found essential for planning of stimulated demand activities based on a multiple case study of three grocery retailers and one wholesaler. A planning process with a longer time horizon is necessary as these decisions requires proper coordination in multiple functions and at supply chain actors weeks and even months in advance, and therefore cannot be part of the daily replenishment process. Generally, the findings indicated a limited focus on tactical planning in grocery retailing both in literature and in practice.

A main challenge for managing stimulated demand activities was a lack of cross-functional coordination propelled by the use of sporadic and separate processes and resources. This resulted in separate plans for different stimulating activities and only a passive involvement of suppliers and customers. It was further observed that only one of the four case companies vigorously evaluated the effect of the demand stimulating activities. The remaining three case companies focused on operational performance measure such as forecast accuracy and inventory levels, which may not comprehensively reflect the success of e.g. a promotion.

To counteract these challenges it was examined how sales and operations planning, from the manufacturing domain, could enhance the align of supply and stimulated demand in grocery retailing. Specifically, an adapted sales and operations planning process for grocery retailing was proposed along with six propositions for how tactical planning could be encouraged and supported in grocery retailing. The proposed process is intended to support the handling of uncertainty in supply and demand by use of an initial step of information gathering, and also combine the various stimulating demand activities into one consensus-based set of numbers instead of three separate plans. Additionally, the six propositions covered areas for leadership, IT usage, performance measures, as well as internal and external integration. This process and associated propositions are intended to support grocery retailers to align supply and stimulated demand.

In short, the theoretical contributions of these findings can be summarized:

- An adapted sales and operations planning process for grocery retailing (Yurt et al., 2010)
- A set of propositions for enhancing tactical planning in grocery retailing with S&OP (Thomé et al., 2014).

Additionally, as a reflection it was discussed how shared information could contribute to more accurate forecasts for stimulated demand activities and how capturing and sharing footfall information in stores could be used to evaluate the effectiveness of the activities. This highlights the versatility of information sharing and further underlines why it is an important capability for grocery retailing.

6.2. Limitations and Future Research

The conducted studies are not without limitations. This section highlights these that are of major concern and propose paths for future research which can reduce the limitations and build further on this work.

All studies in Paper #1 to #5 have assumed good quality of the shared information and a high willingness to share information in the supply chain. Challenges in these aspects are likely to greatly influence the success of reaping the potentials of information sharing. Nevertheless, the studies can provide arguments to practitioners on why engaging in (more) information sharing can benefit the performance of the supply chain. Future studies could, however, examine either how to improve quality or how to utilize non-perfect information.

Another limitation is related to the generalizability of the findings. Except for the multiple case study about stimulated demand activities, all collected data originates from the same grocery retailer. Case studies are generally not intended to generalize findings but merely to empirically shed light on a theoretical concept (Yin, 2013, p. 40). However, to develop theory further, it should still be encouraged to increase sampling size and ensure the findings are robust.

The proposed process for managing stimulated demand is a proposition, and empirical verification is indeed encouraged to test its applicability and impact. Likewise, the results from a simulation only indicate a potential impact in a virtual configuration and do not provide a guarantee. However, practical implementation and verification might be easier for future research now with these preliminary results as arguments for implementation. An empirical study on the value of sharing remaining shelf life information would by nature also take into account more uncertainties than what is possible in a simulation model. In a similar vein, it could be examined if the remaining shelf life information could be estimated based on the outflow of products from the warehouse were the remaining shelf life is known. This should be combined with estimated depletions rate, point-of-sales, and waste information from the stores. Thereby it might be possible to estimate the inventory age in the stores without capturing and sharing remaining shelf life information.

Lastly, future research should also be concerned with inventory allocation of perishables. This study has proposed some rather simple and intuitive guidelines that easily can be implemented at grocery retailers. Use of advanced planning models, or combining the replenishment and inventory allocation into one decision, might improve the alignment between supply and demand even further.

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Appendix A: Questionnaire for Paper #2

The questionnaire contains two main aspects. In Table A.1 each respondent should specify the facet of the information they were sending either upstream or downstream in the supply chain. In Table A.2 each respondent should specify the facets of the information they received as well has how the information was utilized. The questionnaire was originally send in Norwegian and has afterwards been translate to English.

Table A.1: Facets of information sent to customers and suppliers

	Information to customers									**Information to suppliers**							
	Inventory level	Inventory level with remaining shelf life	Forecast	Promotions	Idle/busy production capacity	Status for delivery (timing)	Status for delivery (quantity)	Other		Inventory level	Inventory level with remaining shelf life	Point-of-sales information	Promotions	Forecast	Expected orders (not firmed yet)	Firmed orders	Other
Facets																	
Frequency																	
Aggregation (product, time, and location)																	
Horizon																	
Earliness																	
Number of receivers in the supply chain																	
Receiver (person, department)																	
Modality (telephone, email, portal, EDI, other)																	

Table A1.2: Facets of information received form customers and suppliers and how it is utilized

	Information from suppliers									Information from customers							
	Inventory level	Inventory level with remaining shelf life	Forecast	Promotions	Idle/busy production capacity	Status for delivery (timing)	Status for delivery (quantity)	Other		Inventory level	Inventory level with remaining shelf life	Point-of-sales information	Promotions	Forecast	Expected orders (not firmed yet)	Firmed orders	Other
Facets																	
Frequency																	
Aggregation (product, time, and location)																	
Horizon																	
Earliness																	
Number of receivers in the supply chain																	
Receiver (person, department)																	
Modality (telephone, email, portal, EDI, other)																	

(continues on next page)

Utilization																	
Long-term forecast (e.g. markets, consumer trends, locations, sales channels)																	
Long-term purchasing agreements (e.g. supplier selection, discounts, quantity allocations)																	
Long-term production planning (e.g. determine sizes, locations, allocation among warehouses)																	
Long-term distribution planning (e.g. use of 3PL, route network)																	
Mid-term forecast (e.g. promotion planning, new products)																	
Mid-term purchasing (e.g. inventory policies, lead-time agreements)																	
Mid-term production (e.g. seasonal inventory build up, vacation planning)																	
Mid-term distribution planning (e.g. requirements per route per month, delivery frequencies)																	
Short-term forecast (e.g. daily/weekly replenishment quantities, mark-downs)																	
Short-term purchasing (e.g. firm and adjust orders)																	
Short-term production (e.g. scheduling of individual orders)																	
Short-term distribution planning (e.g. allocation of orders to trucks, maximize load factor)																	
Other																	

Appendix B: Interview Guide for Paper #3 and #4

The interview guide was originally developed in Norwegian and has afterwards been translate to English.

Topics for discussion

- Please provide a general introduction for the automatic replenishment system (ARS). How it functions, the products that are included, number of stores using it, etc.
  - What are the biggest advantage of ARS compared to manual ordering?
  - What are the preconditions for using ARS?
  - Are there any differentiation in the ARS system? How is it made?
  - What improvements could be made to the current ARS?
  - How is the effectiveness and quality of the ARS measured?
  - Should all products be handled through the ARS? Why/Why not?
  - Are there any difference in how products are bought from suppliers if the products (between stores and warehouse) are part of the ARS?

- Implementation
  - How do you decide which stores that should use ARS?
  - Explain the implementation process

- How is the following determined:
  - Products that should be included in the ARS?
  - Safety stock levels?
  - Presentation stock?
  - Shelf space

- Forecasting
  - What is the forecasting process?
  - What forecasting methods are used?
  - On what level is the forecast (daily, weekly, store-level)?
  - What inputs are used for the forecast?
  - How is the performance of the forecast evaluated?

- Challenges with the ARS
  - Most common challenges?
  - How does fresh food products separate themselves from dry and frozen products?
    - Is it possible to include expiration dates?
    - What (FIFO/LIFO) depletion is assumed?
  - How is promotions handled?
  - Is it realistic to use ARS for fresh food products? What is needed?

Appendix C: Interview Guide for Paper #6 and #7

1. Background

- Personal information
  - Current position and responsibilities in the company
  - Working history related to retailing

- Short description of the company
  - Size (nr. of employees, turnover 2015)
  - Retail chains the company is running, or delivers to, description and size (nr. of retail stores, main product category/assortment)
  - Organizational structure, functions and their activities and their relations

2. Medium/long term operational decisions today

- What are the key medium term (4-12 months) planning decisions related to running the operations and demand planning? Please list decisions connected to
  - store assortment planning
  - category management
  - sales and promotion planning
  - product segmentation and allocation (supplier-warehouse-store)
  - inbound planning
  - warehouse planning
  - distribution planning
  - instore planning
  - returns

Planning process

- Please give a general description of the planning process
  - What phases does the process include
  - Please describe planning frequency (daily weekly, monthly, quarterly, other) and planning level (SKU, product group, other)
  - Planning horizon (how long in the future the plan reaches).
  - Are decisions changed between planning rounds?
- What meetings take place and when?
  - Is there an established meeting schedule
  - Is there a pre-specified agenda for the meetings?

Resources

- Is there a unit/function that is responsible for the planning process or individual plans? Are there dedicated persons to conduct planning?
- Who is involved in the different plans/decision making?
- Which functions are involved in different plans and decision making?
- Are roles and responsibilities clear in the process?
- Are there stated owners in each planning process phase?
- To what extent customers and/or suppliers participate in the process? (collaborative planning)

Input and output to/from the decision making

- What input/information is important for making those decisions?
    - What are the most important data sources and data to be captured and used in decision making?
    - Are there any data inputs from suppliers/customers (inventory, available capacity, forecasts, etc.)?
- Are the following aspects included in the planning process? How?
    - New product introductions
    - Promotions/campaigns
    - Uncertainty (sourcing, market)
    - Potential risks
    - Constraints (in addition to available supply)
- What is the outcome/results of the whole process

Integration and consensus

- How the decisions are communicated to other functions and to higher and lower planning/managerial levels?
    - How is it ensured that the planning is aligned with company targets and accepted by the company management?
    - How the decisions and plans are shared and used in running the operations?
- How is it ensured that the plans are integrated?
- How is it ensured that consensus is reached?
- How is the actual balancing of supply and demand accomplished?
- How does the planning process enhance cross-functional integration?

IT support

- What are the main IT tools used in planning?
- Is all relevant data accessible in one system?
    - What about data from suppliers/customers?
- Are the final decisions communicated through an IT system (e.g. the ERP system) or is other methods used?
- Do you have the option to assess "what-if" scenarios?

Performance measurement

(for each of the below please reflect where/how, how often, and which function is responsible)

- Do you measure the planning process effectiveness?
- Do you measure how your operations meet the sales plan?
- Do you measure forecast accuracy? Where (in which function)?
- Do you measure the effectiveness of introducing new products? How?

3. Planning process performance and development needs

- In what aspects is the process running well?
- What are the main performance areas where there is room for improvement (inventories, forecasting accuracy, waste rates, assortment decisions, promotion decisions, integration of plans, alignment with strategy)?
- What are the main challenges or barriers in regards to the planning process itself?
- Dream thinking:
    - From your point of view, how should the process look like (in regards to the areas listed in section 2)?
    - What are the barriers for achieving this?

Appendix D: Sensitivity Analysis of Replenishment Policies

Sensitivity of FIFO Depletion

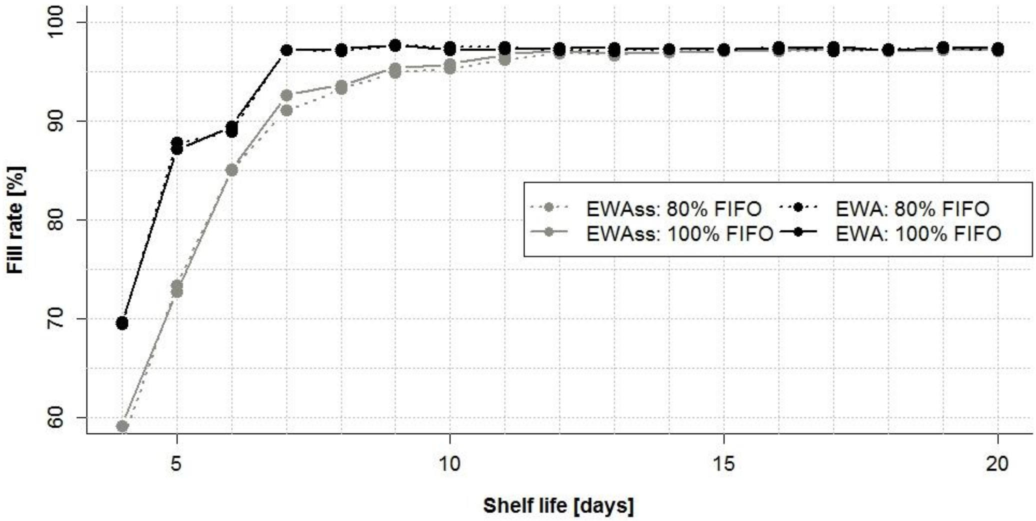

Figure D.1: One year average fill rate across all stores. FIFO depletion 80% and 100%

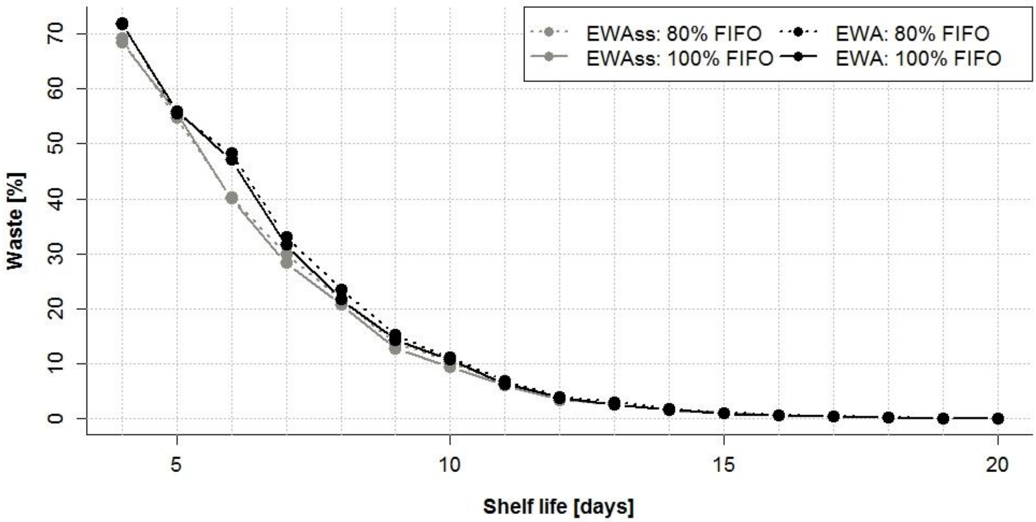

Figure D.2: One year average waste across all stores warehouse. FIFO depletion 80% and 100%

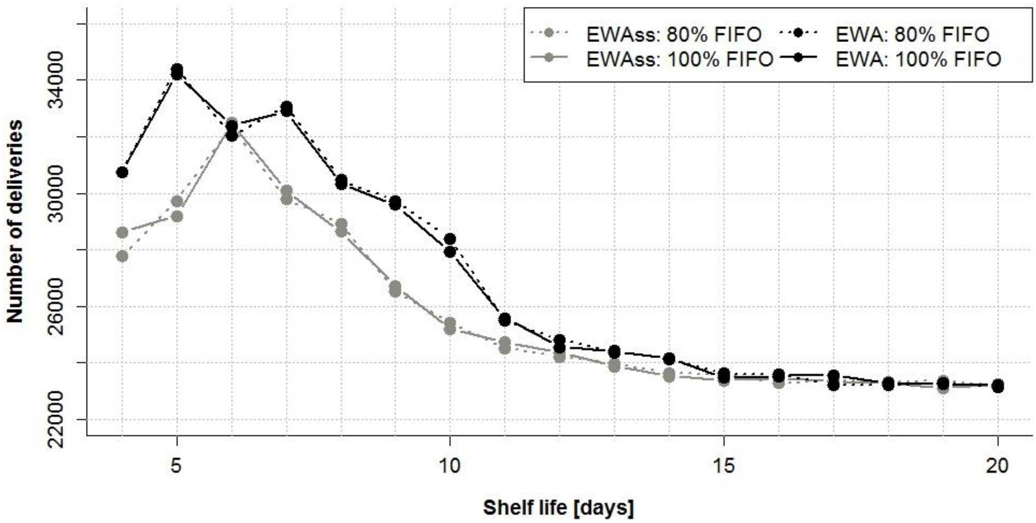

Figure D.3: Total number of deliveries for one year for all stores and warehouse. FIFO depletion 80% and 100%

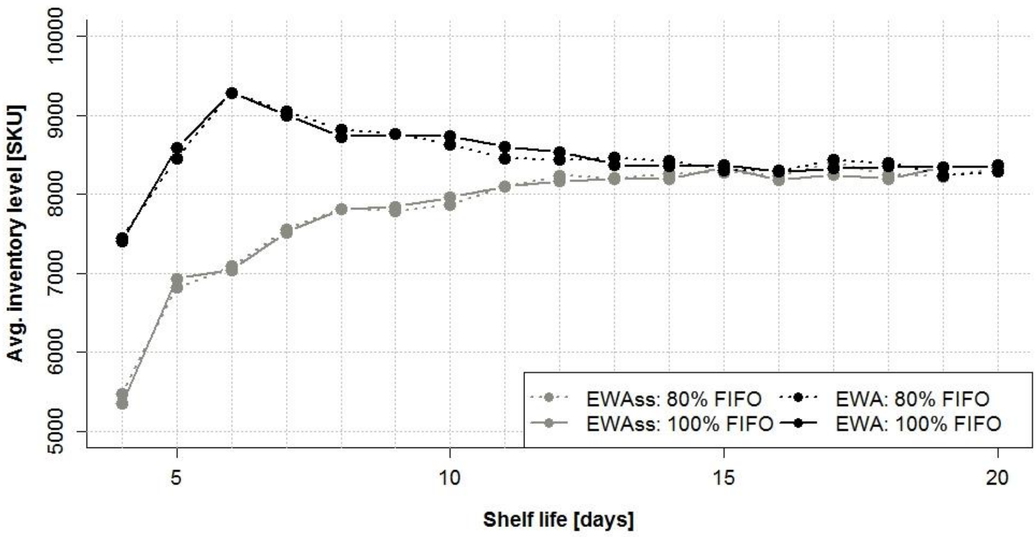

Figure D.4: Average inventory level for one year across all stores and warehouse. FIFO depletion 80% and 100%

Sensitivity of Batch Size

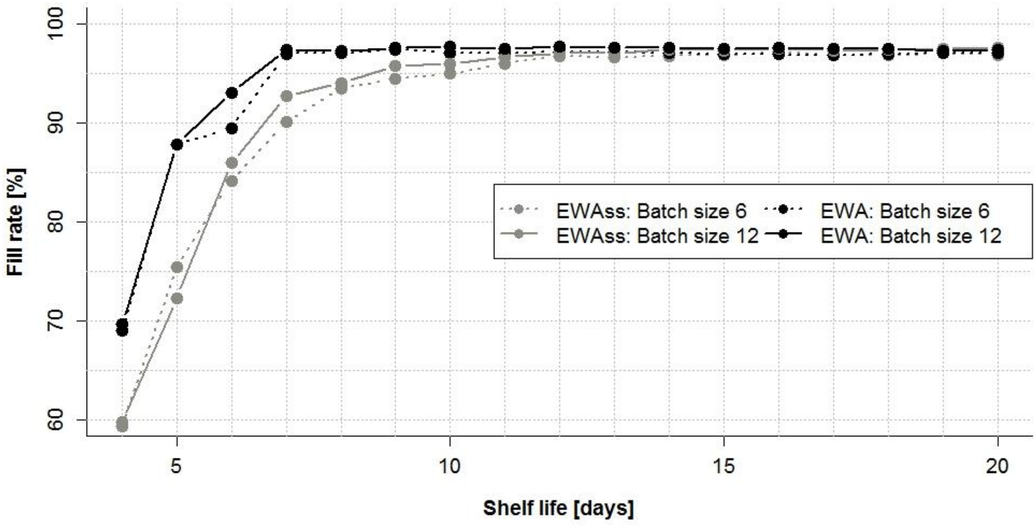

Figure D.5: One year average fill rate across all stores. Batch size 6 and 12

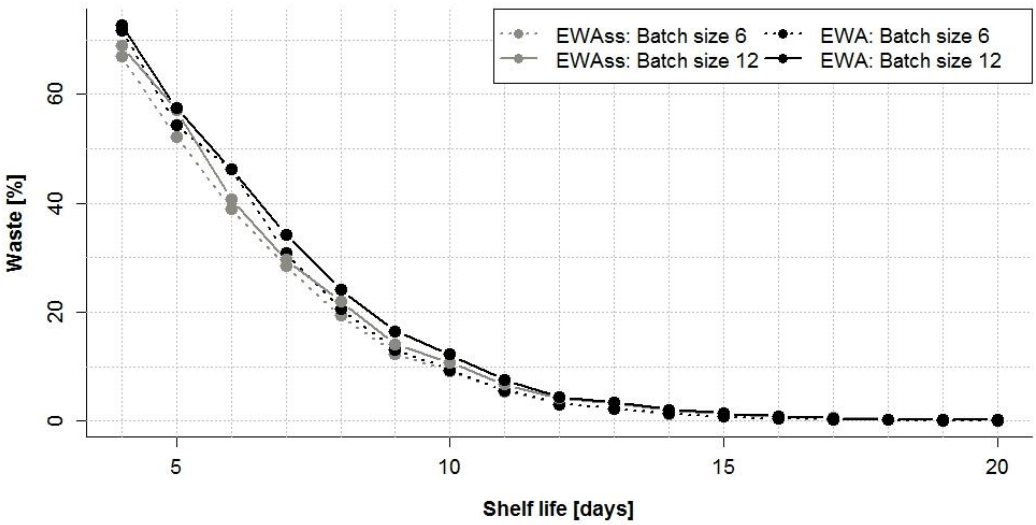

Figure D.6: One year average waste across all stores and warehouse. Batch size 6 and 12

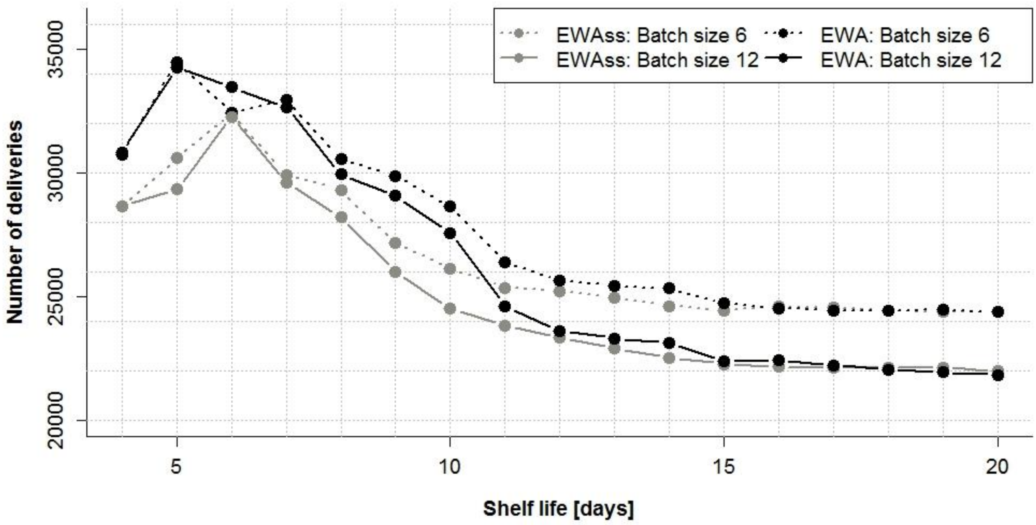

Figure D.7: Total number of deliveries for one year for all stores and warehouse. Batch size 6 and 12

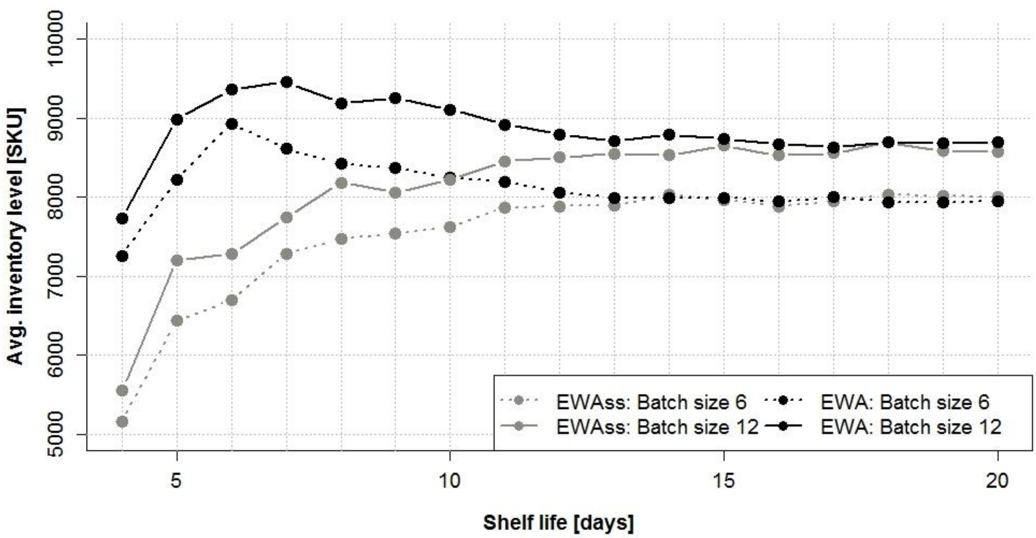

Figure D.8: Average inventory level for one year across all stores and warehouse. Batch size 6 and 12

Appendix E: Sensitivity Analysis of Inventory Allocation Policies

Sensitivity of Batch Size

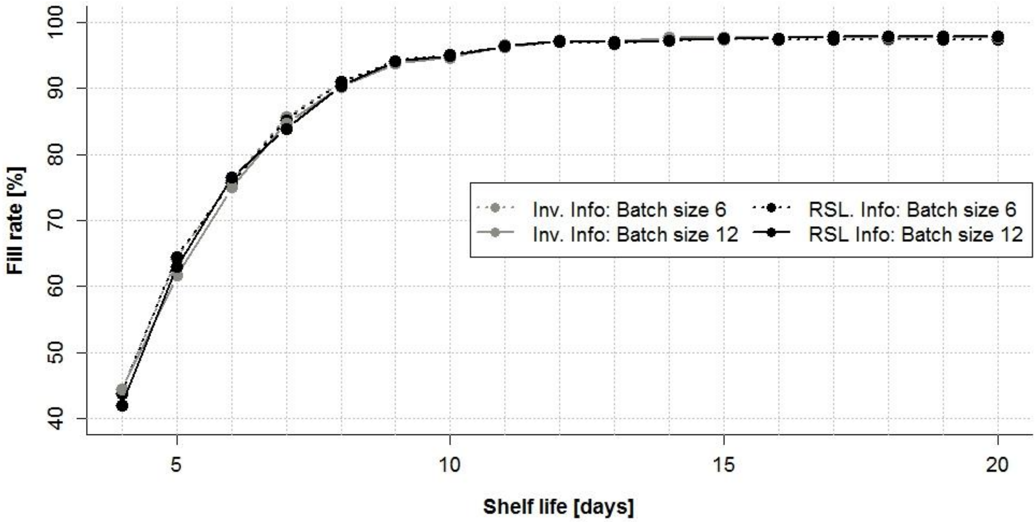

Figure E.1: One year average fill rate across all stores. Batch size 6 and 12

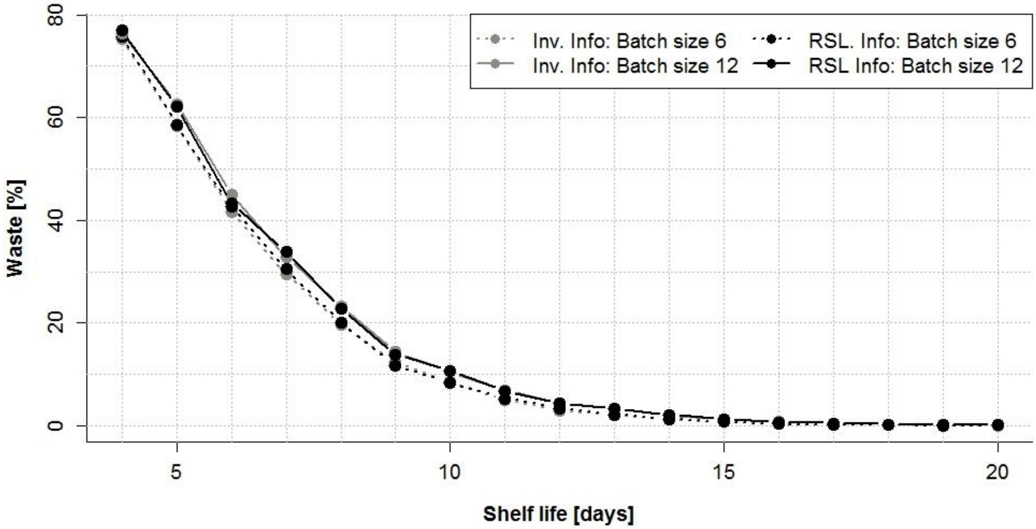

Figure E.2: One year average waste across all stores warehouse. Batch size 6 and 12

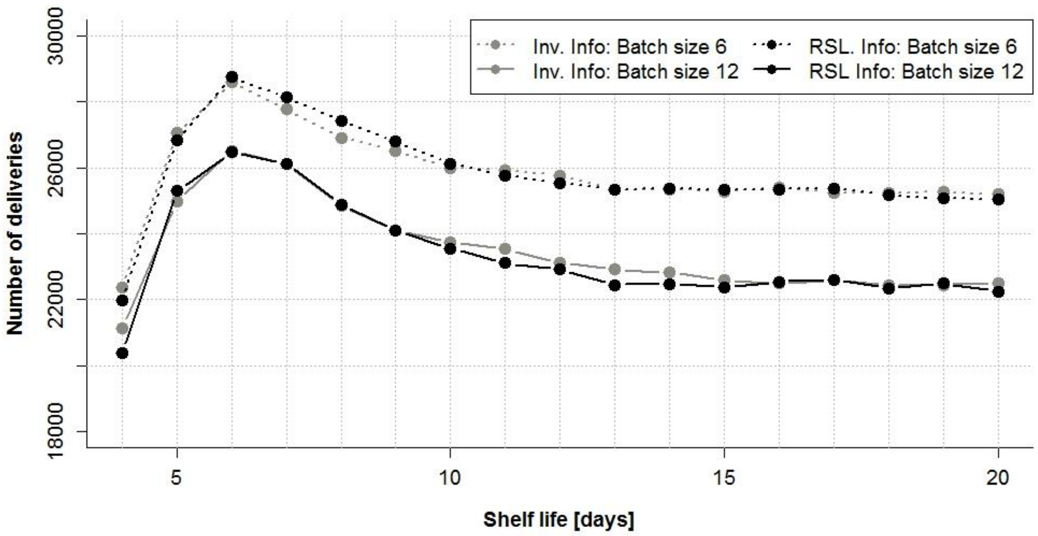

Figure E.3: Total number of deliveries for one year for all stores and warehouse. Batch size 6 and 12

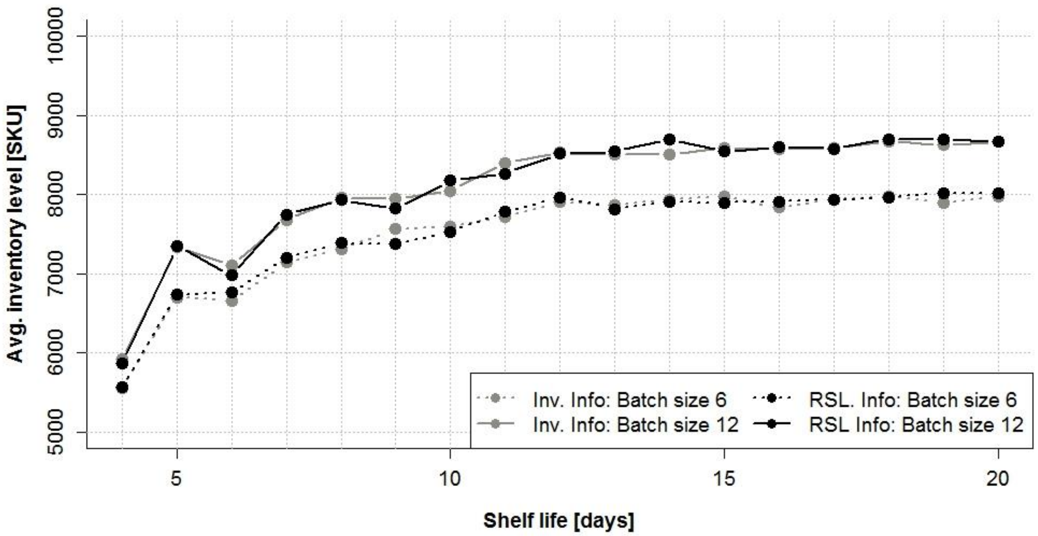

Figure E.4: Average inventory level for one year across all stores and warehouse. Batch size 6 and 12

Paper #1

Linking Information Exchange to Planning and Control: An Overview

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Abstract: This paper creates an overview of previous research which has been conducted related to how information exchange can improve planning and control decisions in order to establish directions for future research. By synthetizing literature reviews, more than 130 unique papers are considered in the analysis. It is identified that most research only examines a dyad relation, and there exist a strong focus on how to improve the order replenishment by using demand and inventory level information. Case studies, simulation models, and inclusion of more complex network structures is suggested for future research.

Keywords: Information Exchange, Planning and Control, Future Research

Published: Advances in Production Management Systems: Innovative Production Management Towards Sustainable Growth. 5-9 September 2015, Tokyo, Japan.

Role of the PhD candidate and declaration of authorship:
Kasper Kiil conceptualized the paper as well as performed the identification of literature and subsequent analysis. The first version of the paper was written by Kasper and afterwards continuously improved by all authors. Kasper presented the paper at the conference in Japan 2015.

Linking Information Exchange to Planning and Control: An Overview

1. Introduction

The constant search for cost reductions and efficiency gains without compromising other performances measures creates an enormous pressure on planning along the supply chain. Exchanging information, e.g. inventory levels, customer demand, fore-cast, among supply chain partners for improving planning and control decisions has been emphasized as an effective mean to improve performance [4] [14] [15]. Some of the cited benefits includes e.g. reduction of bull-whip effect, better and faster re-sponse to customer, greater visibility, reduced inventories, and increased service level [2] [11] [13]. Exchanging information has even been recognized as the core of col-laborative supply chain management [13] [16]. However, there exist no overview of the many small conclusions which have been made [7] [16] [17] and this lacking overview complicates the process of trying to understand how information exchange influences planning and control decisions [12].

This study starts the journey of linking information exchange to planning and control by establishing the necessary overview through examining and synthesizing previous literature reviews. The objective of the study is to answer what research there previously has been conducting related to information exchange and planning and control in order to establish areas of future research.

2. Background

Information Exchange. Information sharing and information exchange appear to be used interchangeably and they both refer to the extent to which operational, tactical or strategic information is available between supply chain members [16] [19]. Information exchange has been studied for decades and its impact on supply chain performance can be traced back to the work of Forrester [6] where the bull-whip effect was first conceived. Causes and recommendations to counteract it has been widely discussed and joint solutions as collaborative planning, replenishment and forecasting (CPRF) has been proposed as well (see e.g. [14] [5]). Today, it is well established that increased information exchange can lead to higher supply chain performance [15] [20]. Even though, it is well-understood that it can lead to higher performance, the road of how to get there is still blurred: “Despite the progress, the research underscored the fact that many SC managers do not fully understand the nature and role of an information-sharing capability. Thus, a proven, well-traveled path with well-defined signposts to the development of this important SC capability has not yet been established” [3, p. 241].

Design of Planning and Control. Assuming information is exchanged with supply chain partners a vast amount of literature investigates how it may be utilized [7] [8]. The application is usually through improved planning and control decisions, i.e. how much to order, when to order, routing decisions, inventory allocations, safety stock etc. [9]. [10] [18] have explained how planning and control, and its underlying decisions, should be designed in accordance with 1) market requirements, 2) product characteristics and 3) process type. However, information exchange is not included as a basis for how planning decisions should be designed. Even though, numerous studies explicitly focus at how those two are connected and how planning and control decisions can be designed (and improved) if specific information is available. Other authors have previously emphasized this concern: “no studies have addressed aspects related to information sharing as a determinant of planning approach." [12, p. 148]. Essentially, there exist no encapsulating framework, or well-traveled path [3], to understand how information exchange influences planning and control decisions, nevertheless the field has still received many valuable but separate contributions [19].

Linking Information Exchange to Planning and Control. Previously, the type of information exchanged has been grouped into 20 categories ranging from demand information to what type of forecasting model or time fence settings the different supply chain partners apply [8]. Planning and control decisions has been divided into eight categories with facility location as the most strategic and order replenishment and shipment decision as the most operational [8]. The purpose of this paper is to connect these two dimensions, and the underlying categories, by generating an overview of which type of information (exchanged between supply chain partners) there previously has been examined to improve planning and control decisions. Secondly, it should be considered *how* this research has been conducted. The applied method (analytical, simulation, etc.) and the supply chain structure (dyad, divergent, etc.) condenses the most important parts of how the research has been conducted, and has also been used in previous review papers [7] [17].

3. Research Design

To grasp the tremendous amount of available literature on information exchange and planning and control literature reviews can provide valuable information. The initial literature search for this study discovered several literature reviews, but none of them directly linked information exchange to planning and control decisions. Therefore, this study assembles previous review papers to create this link and overview. The research process can be divided into two main steps:

Step 1: Locating Studies. First, only published academic articles and proceedings was chosen to be included. Second, to not only rely on a single database four databases (Scopus, ScienceDirect, Google Scholar, and Emerald) were selected. Third, keywords like information exchange, information sharing and collaboration was combined with supply chain at all four databases. Fourth, to reduce the number of articles and ensure a relative novel result a 15-year time period spanning from (including) 2000 to 2014 was selected. 32 papers was identified in this at this stage, this is predominantly because only review papers, and potential review papers, were selected for further evaluation.

Step 2: Selection and Evaluation. A comprehensive review [8] presents a conceptual framework of seven dimensions in order to categorize this type of literature. This framework was later applied in a simplified version with four dimensions [17]. Those four dimensions correspond to what has been discussed in the beginning of this paper and are conveyed in this paper. The first two considers *what* type of information and *which* planning and control decisions. The last two is concerned with *how* the research was conducted:

1. Type of information exchanged
2. Type of planning decision
3. Applied method
4. Supply chain structure

The 32 review papers from the step 1 were read more in detail and only review papers which had specified those four dimensions (for the papers they reviewed) was selected for further analysis. As an example, the review by Giard and Sali (2013) [7] was excluded as they did only specify the planning decision as being either operational, tactical, or strategic which were considered too coarse. Six review papers from the period between 2000 and 2014 was identified to fulfill the selection criteria [1] [8] [13] [17] [19] [21]. Within the six review papers, a total of 176 papers and 131 unique papers had been reviewed.

As the previous review papers provide the main data for the subsequent analysis, their selection process specifies what papers there ultimately are included. The most common keywords used within the six selected review papers includes, supply chain information sharing, flow coordination, supply chain dynamics and collaboration. Some of them have applied a rather broad search approach in operation manage-ment related journals [19] [8] other focus explicitly on modeling papers [1], and some solely on two stage supply chain structures [17]. It should be noted that the chosen method, of only using review papers as the main data source, do not guarantee that all relevant (unique) papers are identified and included, however the method is still highly suitable to indicate previous trends.

4. Analysis and Discussion

Haung et al., (2003) [8] present 20 different categories of which type of information to exchange, and eight categories of different planning and control decisions. The 131 unique papers has been classified according to those categories and are presented in Table 1.

Table 1 specifies that e.g. seven unique papers has investigated the exchange of demand forecast in order to make better decisions related to order replenishment. If a paper has investigated how exchange of demand forecast could be used to improve both inventory allocation and order replenishment a full point has been assigned to both inventory allocation and order replenishment.

Clearly, the first comment from Table 1 is that sharing demand information (i.e. sharing downstream demand, especially by the end customer, with upstream facilities), in order to improve order replenishment (i.e. how a business entity places an order) is the single most investigated relation between information exchange and planning and control decisions. Out of the 131 unique papers almost one-third had this particular relation included. The exchange of inventory levels and demand forecast, to improve decisions related to order replenishment, has also received a great amount of attention.

Planning and Control Decision. Of the eight different planning decisions, order replenishment has been considered in almost all papers; remarkably 114 papers includes this decision. Production and distribution planning is considered in 25 papers while 17 papers investigates shipments (i.e. shipment within the same tier or emergency shipments where one tier is exclude [8]). Surprisingly, decisions related to inventory allocation, safety stock, or capacity allocation has only received very little attention from previous literature. It is surprising as it would be expected that sharing customers forecast or point-of-sales data could improve the focal company's own forecast and hereby obtain lower safety stock levels. Also, if a complete chain is examined, the total inventory level could might be reduced if it is allocated according to where the demand is expected.

Table 1. Number of papers examine the relation between information exchange and planning and control decisions [1] [8] [13] [17] [19] [21].

	PLANNING AND CONTROL DECISION									
INFORMATION EXCHANGED	Facility Location	Outsourcing	Production & distribution planning	Capacity Allocation	Inventory Allocation	Safety Stock	Order Replenishment	Shipment	Not specified	Sum
Demand forecast	0	0	3	1	3	1	7	1	2	18
Production schedule	0	0	4	0	0	0	3	1	0	8
Forecasting model	0	0	0	0	1	0	0	0	0	1
Time fence	0	0	1	0	0	0	0	0	0	1
Inventory level	0	0	1	1	6	3	21	5	3	40
Backlog cost	0	0	0	0	0	0	1	0	0	1
Holding cost	0	0	0	0	0	0	3	0	0	3
Service level	0	0	0	0	1	0	0	0	1	2
Capacity	2	4	3	0	0	0	6	1	1	17
Manufacturing leadtime	0	0	0	0	1	0	3	0	1	5
Cost of process	2	3	3	0	0	0	1	0	0	9
Quality	0	0	0	0	0	0	1	0	1	2
Delivery	0	0	1	0	0	0	3	3	1	8
Delivery lead time	0	0	0	0	0	0	2	0	0	2
Variation of lead time	0	0	1	0	0	0	1	1	3	6
Demand (e.g. POS)	0	1	4	2	2	0	41	3	11	64
Demand variability	0	0	0	1	0	0	6	0	3	10
Batch size	0	0	2	0	0	0	5	1	0	8
Demand correlation	0	0	0	0	0	0	3	0	0	3
Delivery due date	0	0	1	0	0	0	1	1	0	3
Not specified	0	0	1	0	2	0	6	0	8	17
Sum	4	8	25	5	16	4	114	17	35	228

Exchange of Information. Of the 20 different kinds of information possible to exchange demand, inventory level, and demand forecast are the top three followed by capacity and demand variability as forth and fifth. With demand, demand forecast, and demand variability included in top five a tendency of how downstream information, compared to upstream information, can be utilized is indeed present [1]. It could be expected that sharing upstream inventory levels and variability in delivery time may provide confidence further down the supply chain and could help decrease inventory levels. Also, even though the shelf life, or age of inventory, is not included in Table 1 it has been showed how it can improve performance [4].

Supply Chain Structure. To fully understand the research, which previously has been conducted related to information exchange and planning and control, Table 2 presents how it has been conducted by comparing the applied method and the supply chain structure from the 131 unique papers. From the table it can be concluded that nearly half of the papers studies a dyadic structure. Dyadic being the most common supply chain structure followed by serial and divergent which have been in examine in respectively 24 and 23 papers. On the other hand, less than 7% of the papers adopts the more comprehensive network perspective. [8] explains that dyadic structure is too simple to be compared with real supply chains and some of the implications should only be applied on a conceptual level. However, only involving two entities keeps the complexity down and makes it possible to apply an analytical (i.e. calculus and probability) method [19], which may also explain the high occurrence of the analytical method combined with the dyadic structure.

Applied Method. With the high concentration of analytical method and dyadic structure the analytical method is the most common applied method overall. Simulation methods like discrete event simulation and agent based simulation are used across most supply chain structures, while systems dynamic mostly have been applied in serial supply chain structures. Interestingly, no case studies have been included which, besides simulation, appear as a suitable method if a complete supply chain network should be examined. Using the case study approach may also provide new ideas for what type of information to share, and offer examples of what are most common and beneficial to share.

Table 2. Applied method and supply chain structures in the reviewed papers from Table 1 [1] [8] [13] [17] [19] [21].

		SUPPLY CHAIN STRUCTURE						
		Dyadic	Divergent	Convergent	Serial	Network	Not specified	Sum
APPLIED METHOD	Analytical	34	12	4	7	0	2	59
	Systems dynamic	4	0	0	13	0	0	17
	Discrete event Simulation	2	4	3	1	0	0	10
	Mixed integer programming	2	0	0	0	6	0	8
	Game Theory	1	1	2	0	1	0	5
	Agent based modeling	13	5	2	3	2	1	26
	Not specified	1	1	0	0	0	10	12
	Sum	57	23	11	24	9	13	137

5. Conclusion and Future Research

This paper contributes to the current body of knowledge on information exchange by explicitly showing and clarifying what previous research that have been conducted and how it has been conducted. First, the exchange of demand information and inventory levels, in order to improve order replenishment decisions, has received the highest amount of attention. Second, a tendency within information exchange is to investigate how downstream information can be exploited upstream [1]. Third, a common approach is to simplify the problem to a dyad supply chain structure and solve it analytically [8] [19]. Fourth, the use of both simulation and empirical studies are argued to be effective but not fully exploited methods. They also holds the power of analyzing the more complex network structure. Fifth, rudimentary issues, as which type of information to exchange and with whom is still unclear, and no well-traveled path exist [3] [13] [16]. Those five points summaries the outcome of the six review papers. However, to further develop the link from information exchange to planning and control and better understand the how it influences three directions for future research are deduced:

Research Design. It was highlighted that especially the network structure has previously been overlooked. Only studying dyad and simple supply chain structures may not provide the complete necessary knowledge [19]. It is expected, that this could be accommodated by using simulations models or using in-depth case studies where before and after situations are evaluated through essential performance measurements.

Level of Information Exchange. Information exchange can occur at different levels [19] and from the six reviews at least four dimensions defines the level of information exchange a supply chain applies. First, frequency and timeliness; this addresses the issue of how often and how far in advance the information should be exchanged to provide the highest benefit. Second, the information content specifies what type of information to exchange. Third, information detail concerns if information should be exchanged at e.g. SKU level or product family level and if it should be in e.g. monthly, weekly or daily time buckets. Fourth, neighborhood relates to the number of supply chain partners, which should receive and send the information. For future research it could be examined how to actually measure this level of information exchange and provide a generic framework, but also to examine the relationship to different planning and control levels..

Challenges and Benefits. Future research should be concerned with the impact on the supply chain performance and the challenges of implementing it. Some of the challenges of sharing data between individual companies is that it requires a great amount of trust, or willingness, as well as secure technical solutions for smooth connectivity [3]. How can a company safely share detailed forecasts with a supplier, if the supplier also supplies the company's biggest competitors? On the other hand, future research should also give some attention to how the benefit should be measured and distributed between various partners.

This paper present the academic perspectives on information exchange and planning and control. It will be continued with a case study of a network supply chain to examine what type of information there currently is exchanged, if the type of information identified through the six review papers include all types of information relevant to consider, and how the information is linked to the planning and control decisions in the case companies.

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7. Acknowledgements

This paper is part of the Norwegian research project Retail Supply Chain 2020 funded by the Research Council of Norway and participating industrial companies. The four year project was initiated in 2014 and this paper especially contributes on one of the four key research areas of designing new advanced planning and control models through information exchange.

Paper #2

From Information Sharing to Information Utilization in Food Supply Chains

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Purpose: Information sharing has been extensively studied as a key enabler for coordination and integration in supply chains. However, exactly how the shared information is utilized for decision making has only received limited scientific attention in the research literature. The aim of this study is to identify the characteristics of information sharing, and conceptualize how to move from information sharing to information utilization in food supply chains.
Design/methodology/approach: Using a case study methodology together with review of the existing literature we describe the main facets of shared information - which influence the information utilization in a supply chain - and propose a mapping notation for how these facets can be visualized together with the Supply Chain Operations Reference (SCOR) model.
Findings: Information utilization is especially important because more information sharing does not necessarily result in a better supply chain performance unless the shared information is effectively used in the relevant processes in the chain and well-aligned with the requirements for those processes. The proposed notation provides a systematic structure for mapping the information flows, their specific facets, and helps clarify what information is available and how this information can be utilized in different supply chain processes.
Originality/Value: Four facets of information sharing are identified and elaborated for food supply chains, together with a mapping tool that emphasizes the information flows and the utilization of information in a supply chains.

Keywords: Information utilization; Information sharing; Mapping tool; Food supply chain; Supply Chain Operations Reference (SCOR) model

Accepted for publication: International Journal of Information Systems and Supply Chain Management. Will occur in printed form in August 2018

Role of the PhD candidate and declaration of authorship:
Kasper Kiil conceptualized the paper together with Jacques Trienekens and Behzad Behdani during a research stay in Wageningen, The Netherlands. Development, distribution, and the analysis related to the questionnaire was performed by Kasper. The first version of the paper was written by Kasper and afterwards continuously improved by all authors.

From Information Sharing to Information Utilization in Food Supply Chains

1. Introduction

Information sharing, i.e. the *availability* of information from other inter-organizational partners has been of interest for more than half a century (Forrester, 1958; Lee et al., 2000; Montoya-Torres and Ortiz-Vargas, 2014). It is considered to be one of the key mechanisms for coordination across organizations and has shown to enable more accurate forecasts, lower inventory levels, and reduction of bullwhip effect (Mason-Jones and Towill, 1997; Trapero et al., 2012; Zhao and Xie, 2002). However, to fully reap the potential of the shared information, recent studies in the field of supply chain management suggest not only to make information available, but placing a strong focus on how the shared information is and could be utilized at the receiving company (Baihaqi and Sohal, 2013; Jonsson and Mattsson, 2013; Myrelid, 2015).

It has been acknowledged that the utilization and the value of shared information is context specific (El Kadiri et al., 2016; Shaik and Abdul-Kader, 2013). We have chosen food supply chains as the context for this study for two main reasons. Firstly, the characteristics of food supply chains and the products are known to impose special logistical requirements (limited ability to use of buffer inventories, traceability requirements, etc.) (Fredriksson and Liljestrand, 2015; Trienekens and van Der Vorst, 2006). Secondly, due to detailed and fine meshed traceability requirements, starting from the primary producer to the final store, the supply chain as a whole encompasses a vast amount of information (Folinas and Manikas, 2010; Trienekens and van Der Vorst, 2006). Thus, on one hand, food supply chains calls for special logistical activities, and on the other hand, the actors in the chain capture valuable information that may be utilized to a higher extent for those logistical activities.

Utilization of shared information is poorly defined in the existing literature (Jonsson and Myrelid, 2016; Kim and Narasimhan, 2002; Myrelid, 2015). Insights from one of the largest wholesaler and retailer in Norway confirms the necessity and potential benefit of utilize the shared information across the whole supply chain to improve coordination further. On one hand, limited transparency or access to information implies that decisions are taken without considering other actors in the chain. On the other hand, the vast amount of information that is captured due to traceability requirements are mostly used for reporting and safety purpose as other areas of usage has not been systematically identified. These challenges have also been stressed in the literature by (Endsley, 2016, pp. 3-4) stating that: "In the face of this torrent of *information*, many of us feel less informed than ever before. This is because there is a huge gap between the tons of data being produced and disseminated, and our ability to find the bits that are needed and process them together with the other bits to arrive at the actual needed information. That is, it seems to be even harder to find out what we really want or need to know".

To grasp the complexity of all processes and the available and potentially available information in the supply chain and the linkages between processes and information requires a comprehensive and systematic model. According to (Andersson et al., 2014) visualizing the problem can increase the understanding of the problem - not by reducing the complexity but by coping and recognizing it in the visualization. In operations and supply chain management field several methodologies and mapping tools have been proposed to ease this issue by providing structure and overview of this complexity (Aguilar-Saven, 2004; Alfnes et al., 2008; Thakur et al., 2011). Current solutions seem to *either* aim towards depicting facets of shared information (timeliness, content, etc.) (Holweg and Pil, 2008) *or* showing the linkage between the shared information and the decisions processes (Verdouw et al., 2010). However, no concept nor overview exists to identify what, when, and whom to share information with and more importantly how to utilize the received information (Jonsson and Mattsson, 2013; Sahin and Robinson, 2002). In this study, we seek to address this gab in literature by unraveling the concept of information utilization. We do this by identifying facets of information sharing and conceptualize how to move from information sharing to information utilization in food supply chains by proposing a notation for information flows and utilization. This notation is afterwards tested in a case study to demonstration its relevance and applicability for practitioners.

The remainder of this paper is organized as follows. Section 2 briefly presents how the research was conducted and the interaction of empirical data and literature. Section 3 reviews the relevant literature on food supply chains, information facets and utilization. Common mapping tools are discussed in section 4, while section 5 propose a notation for how to visualize information utilization. Lastly, section 6 includes a discussion and conclusion.

2. Methodology

An initial literature search revealed that information utilization has only received limited scientific attention despite its connection and importance for information sharing (Jonsson and Myrelid, 2016; Myrelid, 2015). To examine this gap further we adopted an explorative approach that builds on existing literature and empirical data. We applied a case study approach as it is highly applicable for early investigations where the variables and phenomenon is not fully understood (Voss et al., 2002; Yin, 2013).

2.1 Case selection

A Norwegian food supply chain was selected for this study for three main reasons. First, the food industry is known for recording a high amount of data and for fresh food products, decisions need to be made quickly relying on the information available (Taylor and Fearne, 2006; Trienekens and van Der Vorst, 2006). Second, most of the existing literature on information sharing focuses on dyadic relations (Kembro and Näslund, 2014; Kiil et al., 2015), which simplify the problem but important non-supplier-buyer interactions in the supply chain might not be observed (Huang et al., 2003). Thus, we were motivated to study information flows in a complete supply chain to obtain a holistic understanding. Third, the specific Norwegian food supply chain was selected due to ongoing research protocols, and the existing collaborative mindset between the companies in the supply chain. The wholesaler in this study, owns the warehouses, is closely integrated with the stores and has a long history of common improvement projects with its major suppliers and transport providers. Thus, the traditional barriers of information sharing, connectivity and willingness (Fawcett et al., 2007), were not reflected as an issue for this particular setting. Information quality has also been suggested as a prerequisite for effective results of information sharing (Moberg et al., 2002; Myrelid, 2015). However, all actors agreed that the quality of the information was not the main obstacle as the traceability requirement indirectly ensured high standards for all actors.

2.2 Data collection

The literature on information sharing was studied and in particular literature which aimed to conceptualize information sharing, establish typologies, or which provided descriptive measures to assess the level of information sharing. Additionally, existing mapping tools were reviewed as these are helpful to establish overview and cope with complexity (Gardner and Cooper, 2003).

Four generic facets of information sharing were identified from the literature (this will be elaborated in Section 3.3). These were used to create a questionnaire about the current information flows and ideas for future information flows for the Norwegian food supply chain. The questionnaire was distributed among 25 respondents across the supply chain (see *Table 3*), if they were from the same company they were allowed to answer together. For each type of information the company receives or sends, the questionnaire included questions about frequency, aggregation levels, time horizon, source/receivers, and how far in advance the information was shared. Also, questions about how the actual exchange of information took place and how they used the information were included. Response from all involved companies was received.

Table 3: Respondents of questionnaire and their function

Producers	Wholesaler	Warehouses	Transport	Stores
3 Owners 1 Director of supply chain 1 Functional manager	1 Director of logistics development 1 Head of IT 2 Functional mangers	2 Head of warehouse 6 Functional managers	1 Owner 2 Functional mangers	1 Regional manager 4 Store managers

2.3 Data analysis and validation

Based on the answers from the questionnaire a high-level flow chart illustrating the involved companies was drawn for each type of shared information and the associated facets were added. Practically, this was done by making one flow chart including stores, transportation providers, regional warehouse, central warehouse, and suppliers were drawn to illustrate the material flow. Afterwards, one type of shared information (e.g. point-of-sales data) was added to the chart which showed how often each tier received the data, in which format, in what level of aggregation, etc. Then, new charts with a new information types was made one by one. This was presented and adjusted accordingly at a common 2-hour workshop with the respondents. For each information type it was discussed how it was used at the companies. Ideas for new information flows, both from the questionnaire and from the ongoing discussion, was elaborated in the end of workshop among all respondents.

3. Food supply chains and its information flows

3.1 Characteristics of food supply chains

Food supply chains may be as simple as a local producer selling its products directly to the final consumers, or global supply chains where products flow from farmers, processors, trading units, wholesaler, distributors, and to stores before they reach the consumers (Entrup, 2006). The upstream part of a complete food supply chains typically follows a convergent structure with a high number of suppliers, suppling a variety of different products to a wholesaler. While the downstream part is divergent with a single or few warehouses suppling a high number of stores of different segments (Van der Vorst et al., 2009). The presence of both a convergent and a divergent structure within the same supply chain increases the amount of relationships to coordinate and especially for the wholesaler which is in between. The complexity and associated transparency of the supply chain is to a large extent determined by the amount of relationships and the flow of material and information among these relationships (Trienekens et al., 2012).

The coordination of flow of goods is further complicated in food supply chains due to existence of both supply and demand uncertainty (Romsdal, 2014; Singh, 2014; Taylor and Fearne, 2009). The production of fruit, vegetables, and meat is subject to long throughput times and the exact day, volume, and quality might only be observable at the very end. Additionally, some products like fruit, vegetables, and dairy is subjected to seasonality, and, the quality or availability of those products are not consistent throughout the year (Romsdal, 2014). Regarding uncertainty in demand, at stores, sales have been reported to fluctuate ± 11% around the mean while it fluctuates up to 115% at the producer (Taylor and Fearne, 2009). This clearly demonstrates the existence of demand amplification and room for improving the inter-organizational coordination. Balancing supply and demand in food supply chains is indeed also present. The availability of products in stores is estimated to range from 93.8% to 96.8% indicating a deficit of supply (Aastrup and Kotzab, 2009). While estimates of food waste along the supply chain ranges from 25% to 35% indicating a surplus of supply (Kummu et al., 2012; Parfitt et al., 2010).

Many food products have a limited shelf life and deteriorate over time due their perishable nature, which places unique requirements on logistics (Fredriksson and Liljestrand, 2015; Van der Vorst et al., 2005). For example, storage and transportation in food supply chains has to be accomplished in different temperature zones to account for both ambient, chilled, and frozen products and retained throughout the supply chain to reduce the risk of products perishes. In addition, to provide a long remaining shelf life for the consumers, the products need to move as quickly as possible from the producer to the consumer with limited use of buffer inventories along the supply chain (Kaipia et al., 2013). This calls for a flexible and responsive production facilities and planning capabilities (Van der Vorst et al., 2005). The ad hoc solution for incorrect balance of supply and demand is often for stores to mark down products that are close to their expiration date in order to stimulate demand and avoid food waste (Hübner et al., 2013).

Lastly, for several years companies operating in food supply chains have been obliged to comply with traceability legislation (Trienekens and van Der Vorst, 2006). Traceability can be understood as “the ability to determine the on-going location of products and to trace products back to their origin and used production method” (Trienekens et al., 2014, p. 499). The main purpose and legal argument for implementing a traceability system is due to public food safety and the ability to take prompt actions if required (Thakur et al., 2011; Trienekens and van Der Vorst, 2006). However, as a side effect, of the fine and detailed data capturing along the supply chain, food supply chains are very rich in data which currently may not be fully exploited (Aiello et al., 2015).

3.2 Information sharing and information utilization

Information sharing is defined as the *availability* of operational, tactical, or strategic insights from inter-organizational partners (see e.g. Cao et al. (2010); Kembro and Näslund (2014); Moinzadeh (2002)). In a similar vein is “knowledge sharing” and “knowledge management”. However, these tend to be prescriptive in nature, while information sharing is descriptive and is used as a basis for future decisions (Kock et al., 1997). Information sharing is often discussed as one of the major means to enhance supply chain performance (Baihaqi and Sohal, 2013). It is also known as a key enabler for coordination and integration in a supply chain (Yu et al., 2001). Of course, increased information sharing does not necessarily result in a better performance unless the shared information is effectively used in the relevant processes and well-aligned with the requirements of those processes (Voigt, 2011). Information sharing can be very challenging in practice. Firstly, sharing information needs a level of trust between members in a supply chain (Ebrahim-Khanjari et al., 2012). There is also the need for trust in the sharing technology itself. Companies are willing to share information in a supply chain when they trust both the information sharing system and its alignment with the other companies in the chain. In addition, information sharing is not cost-free and may require significant investment by involved parties (Lee et al., 2000). Accordingly, it is important to clearly understand which information is needed to share, how it can be shared and how it can be utilized in the design and operation of a supply chain (Kim and Narasimhan, 2002). This can be formalized in the term "information utilization". In spite of its importance, the information utilization is a poorly defined concept in the existing literature (Myrelid, 2015). Jonsson and Myrelid (2016) distinguish between four levels of information utilization as presented in Figure 1. At the first two levels the information is available but not connected to processes in the receiving company. At level three the shared information is used at a process, and at level four the information additionally adds value (Jonsson and Myrelid, 2016).

4	**Efficient and effective usage**	The information adds value to the processes (e.g. more efficient or more accurate planning)
3	**Actual usage**	The information received is being used in the processes at the receiving company, but does not necessarily add additional value.
2	**Intended usage**	The receiver has the intention and ability to use the information
1	**Potential usage**	The received information is perceived as useful, no actual usage required

Figure 1: Four levels of information utilization, adapted from Jonsson and Myrelid (2016)

Inspired by the work of Jonsson and Myrelid (2016) we propose the following definition of information utilization in this paper:

> *Information utilization refers to the inclusion of received information, from the supply chain or surrounding environment, in the internal or collaborative decision processes.*

Based on this definition, information sharing (i.e., the availability of information) is a prerequisite for information utilization. The main purpose of information utilization is improving the decision making process in a supply chain. For example, with sharing information more timely or accurate decisions can be made in managing the inventory levels in the chain. The received information should contribute to a better decision or improving the processes of one actor or the coordination of processes of multiple actors in the chain. Additionally, to benefit from information sharing, different processes (by different actors) may have different requirements which are further discussed as facets in the following.

3.3 Facets of information sharing

In the data-information-knowledge-wisdom (DIKW) hierarchy introduced by Ackoff (1989) it can be noticed that structuring of data is necessary to move up the hierarchy (Rowley, 2007). Information utilization is a similar concept and some structure of the shared information is needed before it can be identified where it could be utilized. To characterize and structure information sharing in a supply chain, several descriptive facets are discussed in the existing literature (Barratt and Oke, 2007; Hung et al., 2011; Simatupang and Sridharan, 2005; Uusipaavalniemi and Juga, 2008). These facets are summarized in Figure 2. In principle, these facets define different typologies for information sharing in the chain and should be consistent with the (potential) information utilization.

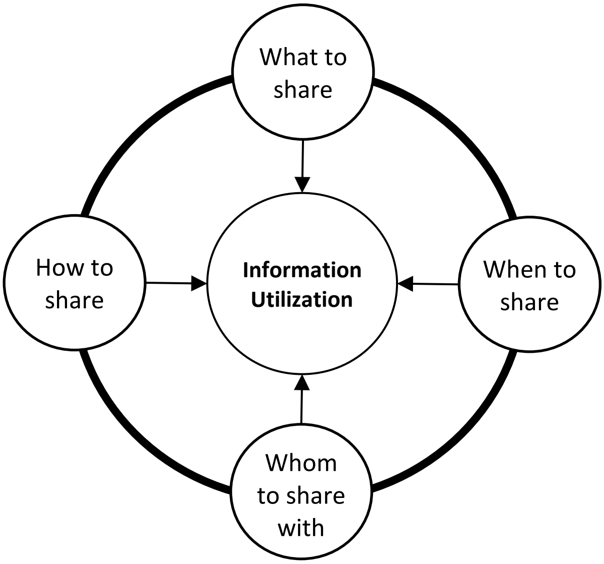

Figure 2: Facets of information sharing, which affect information utilization

What to share relates to the type and the format in which the information is shared between actors. Common types of shared information include: forecasts, promotions, demand or point-of-sales (POS) data, production schedules, inventory levels, idle capacities, planned orders, and firmed orders (Huang et al., 2003; Jonsson and Mattsson, 2013; Kiil et al., 2015; Montoya-Torres and Ortiz-Vargas, 2014; Sahin and Robinson, 2002). Due to the specific context of food supply chain, additional information types such a temperature logs, remaining shelf life of products, the amount of wasted products are also available and can be shared between actors. These context specific types of information, can be used for example in inventory management (Ketzenberg et al., 2015), distribution management (Flamini et al., 2011), and supply chain coordination (Ketzenberg and Ferguson, 2008).

In addition to the type of shared information, the completeness and accuracy of the shared information also influence how the information can be utilized. This is also discussed as information quality in the literature (Gustavsson and Wänström, 2009; Juan Ding et al., 2014; Lee et al., 2002). No unambiguous definition or dimensions seem to exist for information quality (Myrelid, 2015). Here, we consider information quality as being “free from deficiencies” (Juran and Godfrey, 2000), which relates to the completeness and accuracy of shared information.

Additionally, it is common in food supply chains to capture information at a very fine level of granularity, but it can be shared in various level of aggregation. The information can be aggregated in different ways, e.g. time, products, and location (Berente et al., 2009; Jin et al., 2015). For instance, the forecasts or POS data can be shared in weekly or monthly "time" format, per stock keeping unit (SKU) or in different product family levels, and additionally by each individual store or a larger regional level. Lastly, some types of shared information may cover a specific time horizon (Barut et al., 2002; Holweg and Pil, 2008). For example, a forecast may cover 12 months of expected sales, or POS data might be shared for the last year.

When to share relates to the timing of exchanging the information between actors. Timeliness consist of two important aspects; firstly, *earliness* or how far in advance the exchange of information takes place. It is important that the information is delivered in time for the receiving company to react (Gustavsson and Wänström, 2009). The second aspect is the *frequency* of the exchange of information how frequent the receiving company can expect to get an updated or new set of information (Simchi-Levi and Zhao, 2003). Figure 3 illustrates an example to clarify the relation between *earliness*, *horizon*, and *frequency*. The figure shows a forecast of the expected sales from week 2 to 5 (i.e. end of week 4) which is received in week 1. Thus, the *earliness* is one week and the *horizon* covers three weeks. In week 4 a new update of the forecast is expected, thus, the *frequency* is also three weeks in this case.

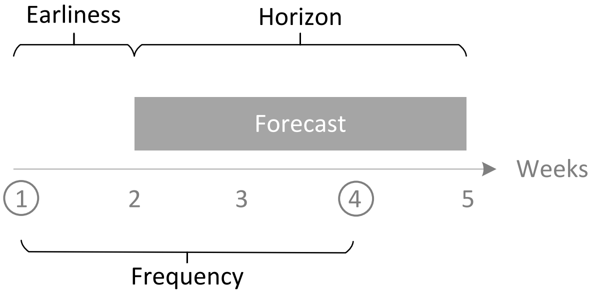

Figure 3: Relation between earliness, horizon, and freqency

The level of *aggregation*, *horizon*, and *frequency* relates to the planning level in food supply chains as illustrated in Figure 4. The figure shows how different facets are related to the hierarchal planning level in the chain. In general, the strategic decisions require information with a longer time horizon and at a higher aggregation level. In this case, the frequency of the information exchange can be yearly or even less frequent. On the other hand, if decisions are on an operational level, the time horizon is shorter, but the level of aggregation is low and the frequency of information exchange increases to continuously control the operations (Souza, 2014; Stadtler et al., 2015). It is essential that these facets of the shared information are matched according to the decision level. Too coarse information may not be applicable, and too detailed information might create an overload of information, which brings limited value (El Kadiri et al., 2016; Simchi-Levi and Zhao, 2003). Additionally, increasing the level of detail also increases the cost of data capturing and processing (Aiello et al., 2015).

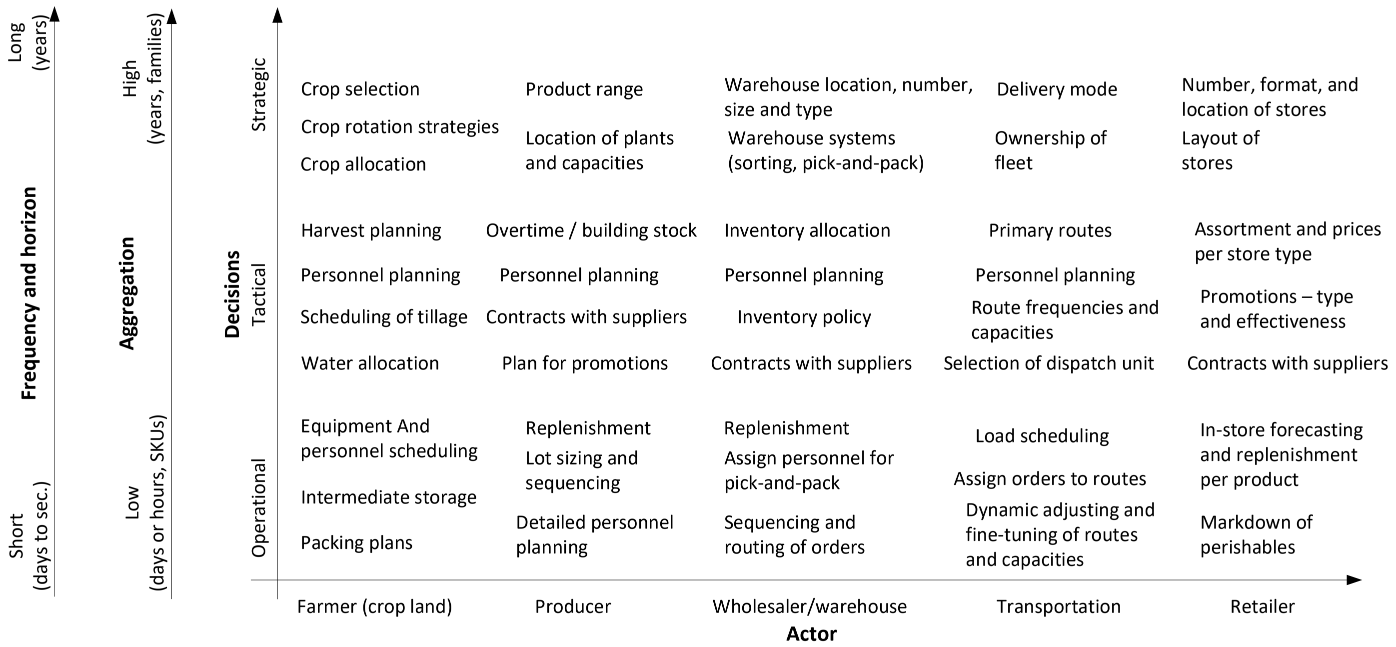

Figure 4: Typical decisions in a food supply chain and its relation to different facets of shared information (based on Ahumada and Villalobos (2009); Dani (2015); Gu et al. (2007); Hübner et al. (2013); Romsdal (2014); Rouwenhorst et al. (2000); Rushton et al. (2014); Stadtler et al. (2015); SteadieSeifi et al. (2014))

Whom to share information with specifies how far the information is exchanged in the chain. It is also referred to as "Information Extent" (Barut et al., 2002; Hung et al., 2011) and describes "how far up or down the supply chain a firm exchanges information". Increasing the information extent has been shown to reduce uncertainty in the supply chain (Hung et al., 2011). In a food supply chain, which both holds the convergent and divergent structure, a complete overview of flows between all actors may become substantially complex. From the perspective of the receiving supply chain actor, the important aspect is to understand the 'source', i.e. where the information originates from. In general, the information may originate from other actors in the chain or from the surrounding environment like weather forecasts or similar.

How to share the information relates to the channel in which the information is exchanged. This is also referred to as modality in the literature (Mohr and Sohi, 1995). The modality does not influence the actual content of the information; however, it may influence how it may be utilized (Huang et al., 2003). The likelihood of the receiving actor to utilize the information might be higher if the information is shared directly through their ERP system compared to a case where it is received via telephone. Four general modalities for information sharing include: 1) direct link between databases or EDI, 2) information provided electronically (e.g. email or web portal), 3) information provided physically (fax, mail, or personal handover), and 4) informal meetings and telephone calls (Uusipaavalniemi and Juga, 2008). The choice of sharing method may also indirectly express the formality of the information sharing among actors (Mohr and Sohi, 1995). Table 4 summaries the four facets and all identified underlying elements of shared information.

Table 4: Facets of shared information

Facet		**Underlying elements**
Content	*What to share*	Type, aggregation, horizon, quality
Timeliness	*When to share*	Frequency, earliness
Source	*Whom to share with*	Supply chain actors, surrounding environment
Modality	*How to share*	Linked databases or EDI, electronical, physical, and informal

4. Information flow and business process mapping

Visualizing, or mapping, information and material flows is known as a key starting point for business process improvements and many mapping tools has been proposed for different purposes (Aguilar-Saven, 2004; Giaglis, 2001). However, there is general tendency to focus on the physical material flow even though it is acknowledged that re-design and process improvement should include the information flow and not only depict the material flow (Berente et al., 2009). As elaborated in Section 3, the facets of the information influence how the information can be utilized in a supply chain. Therefore, we need to visualize the facets of the shared information as well as the current information utilization to support business process improvements. This section assesses the applicability of the most common business process mapping tools and the extensions for visualizing facets of shared information and information utilization.

Several mapping tools, such as flowcharts, role activity diagram, data flow diagram or IDEF maps, support a simple presentation of the *type* of information flow between supply chain actors. The other facets of shared information are generally neglected in these mapping tools.

Furthermore, the utilization is often only considered at a high level, i.e. who the receiver of information is but not the specific processes. The simplicity of these tools might also explain why they are easy to use and effective in communication (Aguilar-Saven, 2004). Value stream mapping is another common mapping tool, which besides information type and the information source represents the frequency of the information exchange. However, facets such as aggregation, modality, and how information is utilized are not included in a value stream map. The supply chain operations reference (SCOR) model also proposes a methodology to map the processes on three levels of abstraction together with the type of information. As indicated by the name, the SCOR model is a reference model and not an actual mapping tool, but its comprehensiveness continues to receive popularity from practitioners (Huan et al., 2004; Verdouw et al., 2010). However, the focus of SCOR is also mainly on the material flows and the facets of information flows are not usually presented in the standard SCOR model.

Extensions to these tools have also been proposed to include more details or to adapt to specific industries. As an extension of value stream mapping, Alfnes et al. (2008) presents a conceptual model with six complementary views of material flow, processes, information, organizational, layout, and planning and control. The information view clearly specifies the modality, but elements like aggregation, earliness, horizon etc. are not specified. Chibba and Rundquist (2009), Holweg and Pil (2008), and Thakur et al. (2011) present comparable approaches, i.e. to mapping material and information flow consisting of a flowchart and an accompanying table with specifications. The flowchart represents the involved actors, the material flow, and information flow in between them. From the accompanying tables additional elements of each information flow related to frequency and horizon (Holweg and Pil, 2008), aggregation (Thakur et al., 2011), or modality (Chibba and Rundquist, 2009) is presented.

Specifically developed for food supply chains, Olsen and Aschan (2010) present a methodology to map the information flow with respect to traceability. The aggregation of the information is rather important here as the information need to be coupled to a traceable unit (Olsen and Aschan, 2010; Thakur et al., 2011). However, aggregation in respect to location and time is not specified as well as facets related to timeliness or modality. An adaption of value stream mapping for food supply chains is presented by Taylor (2005) where information type, source, and frequency is included, as in the original version. Compared to the other presented mapping tools, Taylor (2005) links some of the shared information to processes, e.g. shared demand and capacity plans are used as an input to the weekly planning. It is, however, not consistent throughout the presentation of the methodology. Lastly, Verdouw et al. (2010) shows how the SCOR model can be used to show the information flows and how to link them to the standard processes from the SCOR model in a fruit supply chain. Nevertheless, not all facets of the shared information is included in the version presented by Verdouw et al. (2010). *Table 5* summarizes the enhanced mapping tools presented by various authors elaborated above. The table outlines the degree to which the mapping tools illustrates facets of shared information, information utilization, and its origin.

Table 5: Assessment of enhanced mapping tools

	Content				Time-liness		Source	Modality	Utili-zation	Origin
	Type	Aggregation	Horizon	Quality	Frequency	Earliness				
Alfnes et al. (2008)	x				x		x	x	R	VSM
Chibba and Rundquist (2009)	x						x	x	R	Flowchart
Holweg and Pil (2008)	x		x	x	x		x		R	Flowchart
Olsen and Aschan (2010)	x	x					x			Flowchart
Taylor (2005)	x				x		x		(x)	VSM
Thakur et al. (2011)	x	x							R	Flowchart
Verdouw et al. (2010)	x						X		x	SCOR

R: Depicts only the receiving company and does not link it directly to a decision making process.
x: supported
(x): partly supported

5. Visualizing information utilization with the SCOR model

From *Table 5* it is clear that various mapping tools have been proposed and each of them is able to present different characteristics of shared information. Only two of the identified mapping tools show the information utilization by fully or partly linking the shared information to decision making or processes (see Taylor (2005) and Verdouw et al. (2010)). Additionally, it appears that all facets of shared information are not included in one single tool. This study proposes a mapping notation which emphasizes all facets and facilitates a shift from information sharing to information utilization.

5.1 Notation for mapping information

Similar to the work of Verdouw et al. (2010), we use the SCOR model to map the material and process flow. This is primarily because the SCOR model is acknowledged as one of the most comprehensive frameworks to describe a supply chain and is widely adopted in the industry as a reference model (Huan et al., 2004; Lambert et al., 2005). The SCOR model includes 4 levels with increasing level of details. The first three include standard notation while level 4 is company specific (SCC, 2012). We apply the SCOR model at level 3 for two main reasons. Firstly, when considering a whole supply chain, level 3 provides an appropriate balance between details and complexity (Cheng et al., 2010). Secondly, to communicate across company boundaries, level 3 provides standard processes that all companies are familiar with. If level 4 were applied company specific processes and adaptions will reduce the genericity and the readability across the chain. However, it should be noted that level 3 (and even level 4) describes the processes and not decisions in a supply chain.

To visualize and emphasize information flow with the SCOR model we add an additional layer. Figure 5 depicts the proposed notation for mapping the information flow capturing all four facets from Table 1. For information *content* the aggregation and horizon (when applicable) is written above the shape, while the type of information is centered in the middle of the shape. The right side shows the *timeliness* and the left side shows the *modality*. The form of the shape represents the *source* (here only showed other inter-organizational supply chain actors).

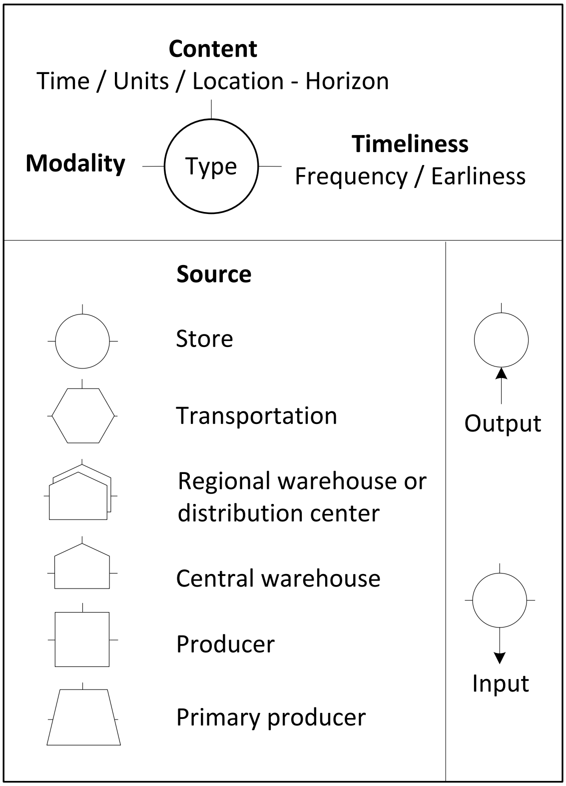

Figure 5: Proposed notation for mapping the four facets of shared information

The information is either an "output", meaning that the information is captured somewhere, which is represented by the arrow going towards the shape. Or, the information is an "input" to a process that is represented by the arrow going outwards of the shape. An important distinction between output and input is the modality and timeliness (left and right side of the shape). If the information is depicted as an output, the information is only captured, but not shared with anyone yet. Meaning, the modality and the timeliness cannot be included at that point. Those two facets should only be shown when the information acts as an input.

Figure 6 presents additional notation to highlight differences between the current information utilization (as-is) and a future improved scenario (to-be). If the shape is colored white with a dotted line around it shows that information - which is already captured and maybe used elsewhere - can be further utilized at another process. A black colored shape highlights that some information is captured along the chain, but currently not included in any process. Lastly, a gray colored shape indicates a completely new piece of information, which is not utilized nor captured yet. Thus, the gray shapes should come in pairs – (1) the information needs to be captured (new info. captured) and (2) it should be utilized at a process (new utilization). With the additional notation from Figure 6 traditional as-is and to-be maps can be made and shown at the same time.

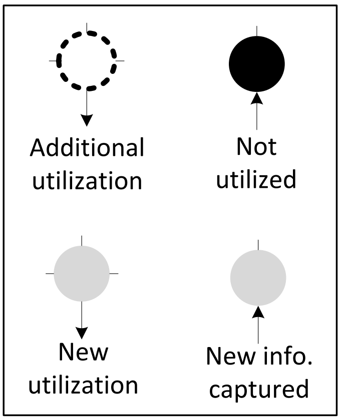

Figure 6: Additional notation for highlighting areas of improvement

5.2 *Combining information flows with the SCOR model*

Based on the data from the questionnaire and the workshop, Figure 7 illustrates the Retail Deliver process (SCOR, D4) at the retail store from the Norwegian food supply chain case company. It demonstrates how to combine the proposed notation with the SCOR model. Table 6 includes the abbreviations used in the figure. From left to right it can be observed that to generate the stocking schedule (i.e. the process of scheduling resources to support replenishment) the store receives and uses forecasts for future promotions from the central warehouse. It is received electronically over a portal, the information is shared six weeks in advance and updated every week. The aggregation is weekly (as the promotion is weekly), on a SKU level, and no specific aggregation in location is made. Lastly, the horizon is one week. Besides the promotional forecast, the stores use two other inputs: planned orders and the sales information. First, the planned orders can be viewed electronically in a portal, and is on a daily SKU level for the individual store. The horizon is typically a couple of days or until next delivery. This information is updated daily and orders arriving the following day (1 day earliness) are possible to see. This information is mainly used to make small adjustments to for the near-future as it only covers the coming days. Second, the sales information is from the store itself, which in this case makes the modality rather informal, but considered every month when the stocking schedule is to be made. The aggregation is daily sales on a SKU level for that particular store. Another example from Figure 7 is the D4.4 process where the shelf is physically replenished. Currently waste is captured on a daily SKU level at each store. But, a potential information (as indicated with the gray color of the circle) to capture could be to daily record the SKUs that are markdown because of short shelf life at each store.

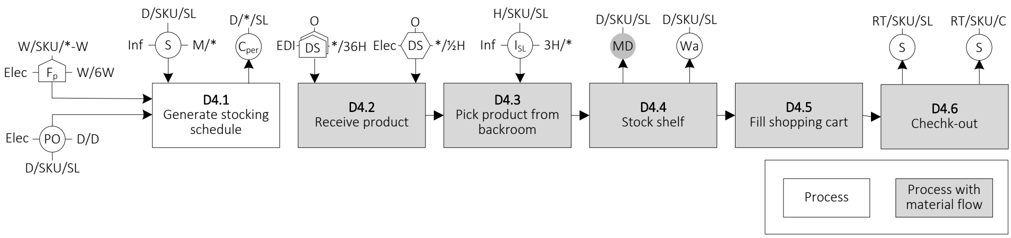

Figure 7: Information flow combined with SCOR Retail Deliver process (D4)

Table 6: Abbreviations in Figure 7 and Figure 8

Time		**Units**		**Locations**		**Modality**	
RT	Real time	SKU	Stock keeping unit	C	Consumer	Inf	Informal
H	Hourly	B	Batch size (D-pack)	SL	Single location	Phy	Physical meeting
D	Daily	O	Order	R	Transportation route	Elec	Electronically via SMS, email, portal, etc.
W	Weekly	TG	Temp. group (dry, chilled, frozen)				
M	Monthly					EDI	Linked databases or EDI

Information Type		Special character
C_{per}	Capacity plan, personnel	* Not applicable for that given information type
C_{tr}	Capacity plan, transportation	
DS	Delivery status (time and quantity)	
FO	Firmed orders	
F	Forecast	
F_p	Forecast, promotion information	
I	Inventory level	
I_{SL}	Inventory level with shelf life	
MD	Markdown	
PO	Planned orders	
PO_p	Planned orders, promotion	
S	Sales	
TL	Temperature log	
Wa	Waste	

By displaying the input and output separately it can be visualized that some information is captured but not yet shared and utilized, or it can be reflected that the information may be shared at a higher level of aggregation that how it was captured. Obviously, a piece of information cannot act as input if it is not captured somewhere, just as the granularity level for the input cannot exceed the granularity level of how it is captured. In Figure 7 the sales information is captured at D4.6 in real time, but aggregated to daily level before it is used as an input in process D4.1. For the consumers with a loyalty card, the sales information is captured in real time as well and additionally linked to the specific consumer. This is used afterwards at the wholesaler to generate consumer specific promotions.

5.3 Interpreting information flows in a food supply chain

As the main purpose is to give structure to the information flows in a food supply chain and not just a single entity, Figure 8 illustrates the information and material flow for the regional warehouse, the transport provider, and the store where Figure 7 is the lowest swim lane. The primary producer and the processor is omitted due to space limitations. Figure 8 is also developed based on the data obtained from the questionnaire and the workshop with the Norwegian supply chain. The combination of the SCOR model and the proposed notation provides a structure for the current information utilization at the three actors and highlights areas of improvement simultaneously.

5.3.1 Current information flows

All white shapes illustrates the current information flow, all relevant facets of the information, and how the information is utilized for different processes. By focusing on the form of the shapes, information from other supply chain actors can easily be identified. In the lowermost swim lane in Figure 8 the information in circles are from the store itself, and information in other shapes represents information from other actors. For instance, the forecasts from the central warehouse (shaped like a house), the delivery status from the transport provider (hexagon), and delivery status from the regional warehouse (two houses) are clearly emphasized.

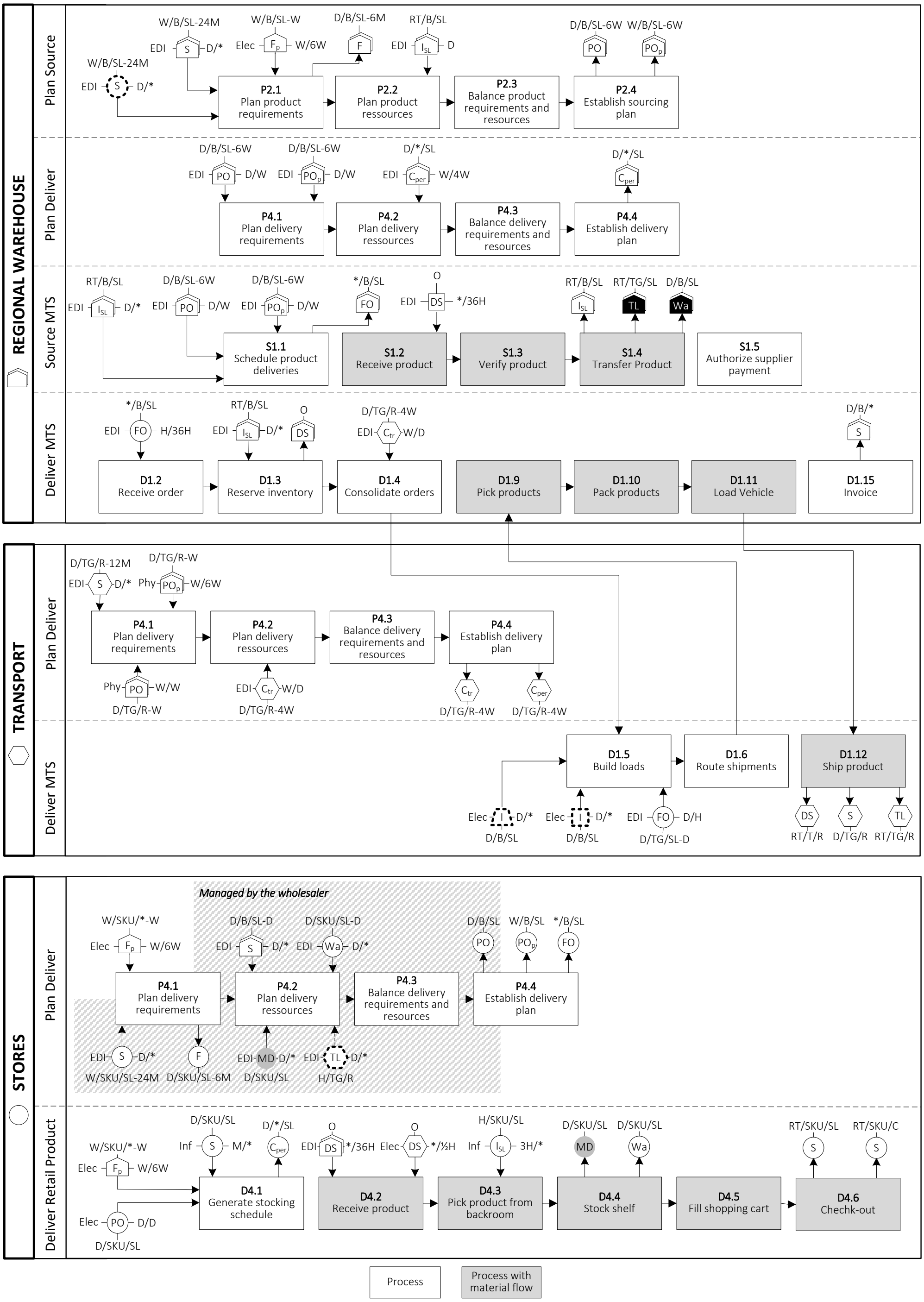

Figure 8: Information and material flow from regional warehouse to store

The area with gray stripes at the stores indicates a continuous replenishment program (CRP) where the wholesaler receives sales information from the stores to generate a statistical forecast (P4.1). Based on waste information from the stores and previous sales to the stores (P4.2) an estimated inventory balance at the stores are calculated and together with the forecast an order proposal is generated to the stores. The stores review and confirms the order in the end (P4.4). The CRP solution do not handle promotions, thus the planned orders for promotions is made by the stores itself.

5.3.2 Captured but not utilized information

It can be noticed by the black shapes that the temperature log and waste information from the regional warehouse is currently only captured, but not systematically included into any decision-making processes. The temperature registration is due to traceability requirements; however areas of utilization could be identified for this information.

5.3.3 Additional utilization of captured information

In Figure 8 four areas of further utilization of information - that is already captured - can be identified. If the transport provider could access both primary producers and processors inventory levels through a portal it would enable a better planning of transportation routes. After delivering goods to stores the truck could be scheduled to pick-up goods from producers to increase the utilization of the truck capacity on a round trip. Another type of information is the temperature log from the transportation provider. Currently this is not utilized at any processes, however this type of information can be used to estimate remaining shelf life of perishable products, and act as input for calculating new replenishment quantities (Ketzenberg et al., 2015). Lastly, it became clear that the forecast for the regional warehouse is currently based on previous orders to the stores and not on POS data - even though this data is accessible in the same system. Thus, POS data could be utilized throughout the chain to establish a common forecast and reduce the bullwhip effect (Lee et al., 1997).

5.3.4 New information and utilization

A common practice for perishable products with short remaining shelf life is mark-down of prices in order to stimulate demand and reduce food waste (Hübner et al., 2013; SCC, 2012). However, if this represents a large amount of the products available in the store it needs to be considered for the coming replenishment order. Thus, as illustrated in Figure 8 this amount of products, which is mark-downed and soon to expire, should be captured daily and utilized when calculating the next replenishment quantity.

5.3.5 Aligning information and processes

With existing knowledge about the individual processes and underlying decisions at each company Figure 8 also provides a structure to align the information and processes, e.g., if a process is executed weekly, but the information is only updated monthly these two can be aligned to have the same frequency. Similar observations can be made for the level of aggregation, if the information should be received some days earlier or if the modality should be changed to facilitate an easier integration and utilization of the information. For example, in Figure 8 it can be observed that the information, which are utilized in P4.1 at the transport provider, comes with different time horizons and frequencies. This could be made more consistent and aligned to fit the process.

6. Usage and implications

From a managerial perspective, the diversity of numerus information flows to and from various actors in the supply chain creates a complex and hazy situation - both of what is needed and what is possible in regards to information utilization in the supply chain (Endsley, 2016). To establish a complete map of information and material flow as in Figure 8 five main steps are proposed in Figure 9. However, a prerequisite before starting with step 1, is to decide how generic or specific the final result should be. I.e. should it reflect the interaction with the main group of suppliers and customers, should it represent all products, or maybe only a specific product family? The SCOR model has specific processes for make-to-stock and make-to-order products, thus making a unique map for each type might be desirable to reduce complexity. Thus, several maps might be necessary if there is a high number of very different supply chains actors and products.

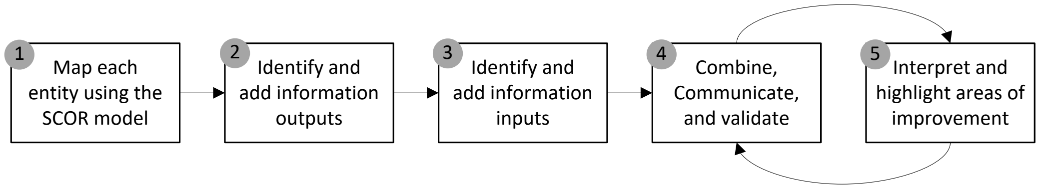

Figure 9: Steps to establish a complete map of information and material flow

Step 1 - Mapping each supply chain using the SCOR model should be carried out, objectively, by each individual company. Starting with SCOR level 1, progressing down to level 2, and ideally level 4 or at least identify the key decisions made within each level 3 process[1]. Step 2 and 3 – identify the facets of information output and input and add to the SCOR level 3 map. It is beneficial to focus on the output and input separately in the beginning because it makes the mapping process simpler. But, more importantly it will be different personal that should be involved in the two steps, and can provide knowledge about what information that is currently captured in-house (e.g. IT or production department) and how information is utilized (e.g. planning department). *Ideas* for future information flows, i.e. those in Figure 6 should also be noted at these steps. Step 4 and 5 – establish a common supply chain map with information inputs and outputs based on the individual maps from each company to highlight and discuss areas of improvement. Here, it is essential that each company has its own ideas and reflections on where gabs might exist and how to close these before meeting with representatives from the rest of the supply chain. It is crucial that a valid map of the current situation is established and agreed upon before discussing future scenarios. As indicated in Figure 9 over time, the steps of validating and identifying areas of improvement will be a continuous and iterative process.

The specific context and the facets will provide understandings for how the information can be linked to processes and utilized. However, to ease the identification of this link, between information and processes, it might be useful to group and consider the information types in three generic time periods: past, current, and future as shown in Table 5. Hereafter, at least two approaches to proceed exists.

[1] Software like ARIS, Visio, or LucidChart could be potential solutions to draw the actual map

Table 7: Grouping of information types

Past	Current	Future
Sales	Inventory level	Capacity plans
Temperature log	Mark-down	Forecasts
Waste		Planned orders
		Delivery status
		Firmed orders

First, depending on the time period each information type can bring different insights. Information in the “past” category is highly applicable to analyze and search for patterns, explanations, and correlations. E.g. identification of seasonal patterns, substitution effect, or promotional effectiveness. Information in the “current” category explains the status as it is now. This is especially true if the information is received in real-time or close to real-time. This does not only include inventory information or products which are marked down, but could also include location information of trucks in a fleet, or current temperature or pressure in a machine. Lastly, information in the “future” category provides insights to what is expected to happen. Clearly, the task with this information is to compare and reconcile with one’s own current plans and identify any opportunities or challenges. E.g. is the total volume in the forecast the same or is additional shifts necessary or other actions be initiated?

Thus, overall three essential questions relates to each category (1) what happened?, (2) what is happening?, and (3) what is (expected) to happen? By considering the information in this way, i.e. what answers they might bring with them, it might be easier to identify how to utilize it.

The second approach is to use the information in planning processes - which is planning of *future* activities. Thus, information from the “past” and “current” category should be processed or combined to express something about future expected events. Clearly, sales information can be used to generate statistical forecasts. Similar, the temperature log can be used to estimate deterioration rate and together with products that are marked down this can give an estimate of when the products expire and when a new replenishment is required. Another example is to combine the current inventory level with the forecast, which will provide an understanding of if the next replenishment is highly critical or if can be distributed to another actor in case of shortage. Thus, the second approach seeks to process the information to make it express something about future events.

As demonstrated in Figure 8, the proposed mapping tool provides a systematic structure to evaluate the information available and which processes from the SCOR model that is present in the system. Mapping the current information flows will facilitate and secure a common understanding across supply chain actors. This serves as a foundation for enhancing inter-organizational coordination, identify potential valuable pieces of information from other actors, or even from the surrounding environment as well as where to utilize this information

7. Conclusion

The aim of this study was to identify facets of information sharing and conceptualize how to move from information sharing to information utilization in food supply chains. Due to shelf life limitation, perishability of products, seasonality, and wide assortment range, food supply chains have some special logistical requirements. On the other hand, a vast amount of information is regularly collected along the chain – especially due to safety and traceability legislations. The general idea is to use this information - beyond the safety and traceability purposes - for improving the processes along the chain. The information utilization concept strives to emphasize this idea. To facilitate the information utilization, a mapping tool that provide a structure to the vast amount of available information and the linkage to the supply chain processes is proposed in this paper.

7.1 Contribution to theory

Several studies discuss and quantify the value of sharing information (Baihaqi and Sohal, 2013; Huang et al., 2003; Lee et al., 2000), but how the information is utilized to measure this value has only received very little consideration (Myrelid, 2015). To bring attention to this poorly defined topic Jonsson and Myrelid (2016) propose the very first conceptualization of it. We extend this research by a three-folded contribution.

Firstly, from a scattered amount of literature we synthesized previous identified facets of information sharing (Barratt and Oke, 2007; Hung et al., 2011; Uusipaavalniemi and Juga, 2008) and further elaborated the underlying elements such as aggregation level, horizon, and earliness for food supply chains (Fredriksson and Liljestrand, 2015; Jin et al., 2015). These facets provides structure to move in the DIKW hierarchy (Rowley, 2007). From Figure 4 it is clear that the facets of shared information determine how the information can be utilized for different hierarchical planning decisions. Consequently, it is essential to fully understand these facets of both the current and new potential information flows.

Secondly, we define information utilization to clarify the concept and in order to set the boundaries for further research on the topic itself and against surrounding research topics. Information sharing is the act of making information available to other actors in the supply chain, while information utilization is characterized by inclusion of the shared information into various decision processes. This may appear to conflict with the four phases presented by Jonsson and Myrelid (2016) in Figure 1. They view it as a gradually increase in maturity, where our definition clearly distinguishes between information sharing and information utilization. However, the underlying message is equivalent. It is essential that companies, and supply chains, move from just making information available to include and benefit from the shared information in the planning processes.

Thirdly, to facilitate information utilization we draw on the ideas from various mapping tools and references models. Especially, we build on the ideas by Verdouw et al. (2010) by highlighting information flow together with the SCOR model. Maps are powerful tools because they allow us to see what is too large and too complex to grasp. The proposed mapping tool extend existing mapping tools by (1) showing all facets of the shared information, which is necessary to identify how to utilize the information. (2) Emphasizes the linkage between information and processes. Lastly, (3) it separates information flow to output (capturing) and input (information utilization), which makes it possible to identify available information which may not currently be utilized and the information that is currently being utilized.

7.2 Limitations and future research

This study has several limitations and should be used to guide further research. The study has only considered one case, thus the application of the proposed method has only been tested for this particular case and cannot necessarily be generalized to other cases. However, the SCOR model is rather generic and is developed to fit a variety of settings (SCC, 2012), but it could be investigated if all relevant information types for food supply chains have been identified and considered. Moreover, for the particular food supply chain under investigation information quality was not considered or reported as a challenge. Thus, it was assumed that all information was free of error. It has previously been shown that the quality of shared information affects the performance of food supply chains (Juan Ding et al., 2014), thus it should be studied further and incorporated to a greater extent.

Lastly, we choose to combine the notation for information flows with the SCOR model due to its generic abilities and its adoption in practice. However, for the unfamiliar reader a simple flow chart of the material flow may be easier to interpret than the SCOR model. It could be investigated if the proposed notation combined with other mapping tools, which also depicts the decision processes, would make it even easier visualize the information utilization.

8. Acknowledgement

The authors gratefully acknowledge the assistance provided by the Norwegian Research Council (NRC) for the financial support of Retail Supply Chain 2020. Also, we thank the participating case companies which together with the NRC enabled this study. Lastly, we thank Peter Falster for his valuable comments and Chris Martin for assistance in editing this paper.

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Paper #3

Sustainable food supply chains: The impact of automatic replenishment in grocery stores

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Abstract: The aim of this study is to empirically investigate the impact of automatic replenishment on food waste metrics in grocery stores. The work has been designed as a case study focusing on the replenishment process among various stores and a single warehouse. Food waste metrics of products ordered through an automatic replenishment program are compared against products ordered manually. Specifically we contrast food waste, remaining shelf life and availability at the stores for a variety of products with different shelf life. The study suggests that by utilizing an automatic replenishment program the stores can reduce their level of food waste by up to 20% and their products have a longer remaining shelf life without compromising on-shelf availability. The study also indicates that the impact of the automatic replenishment program is dependent on the product's shelf life. Those products with a shelf life of between 51 and 110 days experience the highest impact, while products with a shelf life below 30 days experience a low or even negative impact. The study extends the current understanding of automatic replenishment programs. The key point for practitioners is to apply appropriate replenishment programs according to the product characteristics and especially the shelf life.

Keywords: Information sharing; food waste; remaining shelf life; automatic replenishment; shelf life

Published: Production Planning and Control (2018), volume 29, issue 2, pp. 106-116

Role of the PhD candidate and declaration of authorship:

Kasper Kiil conceptualized the paper. The data was collected by Lukas Chabada with support from master students and Kasper for the store visits. Kasper conducted the analysis and wrote the first version of the paper, which afterwards was continuously improved by all authors.

Sustainable food supply chains: The impact of automatic replenishment in grocery stores

1. Introduction

Sustainability concerns are an essential part of the operations in food supply chains. This paper focuses on the economic and indirectly the environmental dimensions of sustainability by investigating food waste metrics. It is estimated that 25%-35% of all food produced ends up as food waste (Kummu et al. 2012; Parfitt, Barthel, and Macnaughton 2010). Food waste is not only an indication of economical loss in the phase where it is discarded. It also indicates that natural resources such as soil and water has been wasted at the farm gate level and unnecessary pollution has been added to the environment from transportation along the supply chain (Bourlakis et al. 2014; Gerbens-Leenes, Moll, and Uiterkamp 2003; Maloni and Brown 2006).

Ten to twenty percent of all food waste occur at the retailer phase (Kummu et al. 2012; Parfitt, Barthel, and Macnaughton 2010). This wastage is often explained by the increasing variety and volume of fresh food products on display, a poor understanding of demand, low transparency, inadequate replenishment decisions and forecasting difficulties in a push system (Kaipia, Dukovska-Popovska, and Loikkanen 2013; Mena, Adenso-Diaz, and Yurt 2011). Also, if products arrive at the stores with a too short remaining shelf life the risk that the products may expire is higher either in the store or after the consumer takes them to their home (Kaipia, Dukovska-Popovska, and Loikkanen 2013; Mena, Adenso-Diaz, and Yurt 2011).

The replenishment decision in food supply chains is challenging because the limited shelf life require the products to move quickly from the primary producer to the end consumer, and limits the possibility of using buffer inventories (Hübner and Kuhn 2012; Kaipia, Dukovska-Popovska, and Loikkanen 2013). Also, the increasing product variety (Trienekens et al. 2012) and non-stationary demand throughout the week (Taylor and Fearne 2009) makes replenishment decisions difficult to manage. The replenishment is central for the performance of food supply chains as it balances availability on one side and the risk of food waste on the other. If too few products are ordered the stores risk a stock out and if too many are ordered the products may end spending too much time in store reducing remaining shelf life and worst-case end up being wasted.

It is estimated that half of the food losses can be prevented through better supply chain management (Kummu et al. 2012). In this regards one highly recommended remedy is better information sharing and improved replenishment decisions (Kaipia, Dukovska-Popovska, and Loikkanen 2013; Mena, Adenso-Diaz, and Yurt 2011; Taylor and Fearne 2009). Specifically, Mena et al. (2014) propose that improved transparency of demand information upstream in the supply chain can help reduce food waste (Proposition 1b, p. 152).

To benefit from information sharing the key element is not only the information shared but also how the information is utilized by the receiving company (Baihaqi and Sohal 2013; Jonsson and Mattsson 2013; Barratt and Oke 2007). In food supply chains shared information is often utilized for replenishment decisions through an automated replenishment program (ARP) (Van Donselaar et al. 2010). The information is used to gain insight into demand and inventory levels in order to improve the replenishment decision. Theoretically, it has been demonstrated that this type of information sharing and replenishment method has a positive impact on supply chain performance such as reduced uncertainty, reduced bullwhip, reduced inventory levels or increased forecasting accuracy (Lee, So, and Tang 2000; Disney and Towill 2003; Aviv 2001; Costantino et al. 2015; Titah, Shuraida, and Rekik 2016; Kelepouris, Miliotis, and Pramatari 2008). Average performance improvement of information sharing has been reported to 1.75% (Chen 1998) and 2.2% (Cachon and Fisher 2000). However no studies have investigated the impact of these replenishment methods from a sustainability perspective. The reported performance increase varies substantially between studies and may be explained by different contingency factors such as different demand patterns, batch sizes and lead times (Jonsson and Mattsson 2013; Ketzenberg et al. 2007).

Automatic replenishment programs are enabled by an increased amount of shared information between the supply chain partners. This increased transparency makes it possible to coordinate replenishment decisions more effectively and synchronize orders to balance availability and food waste metrics. However, empirical research comparing the impact of ARP on food waste metrics and other possible contingency factors is very limited in previous research (Kaipia, Dukovska-Popovska, and Loikkanen 2013) even though it is expected to have a positive impact (Mena et al. 2014).

In this study, we empirically investigate the impact of ARP on food waste metrics in grocery stores in Norway. Specifically, we compare food waste levels and remaining shelf life at grocery stores by analyzing two situations: (1) when orders are placed manually and (2) when ordered are placed through an ARP system. We do this within a case study of a large Norwegian grocery retailer. The findings add to the research literature within this specific area specifically using a sustainability perspective.

The remainder of this paper is organized as follows. Section 2 contains a review of relevant literature for automatic replenishment programs in food supply chains. Section 3 argues for the selected case study methodology used in this study, provides a description of the cases and explains how the data has been collected and analyzed. Section 4 presents the analysis and results. In Section 5 we discuss the findings and conclude where an agenda for further research is also presented.

2. Automatic replenishment in food supply chains

To increase interfirm coordination and improve the replenishment process a number of sophisticated supply chain practices known as automatic replenishment programs (ARPs) have been developed during the last decades (Yao and Dresner 2008; Arshinder, Kanda, and Deshmukh 2008; Daugherty, Myers, and Autry 1999; Sabath, Autry, and Daugherty 2001). Automatic replenishment programs include Efficient Consumer Response from the food industry (Kurt Salamon Associates 1993), Quick Response (Daugherty, Myers, and Autry 1999), the Continuous Replenishment Program, and Vendor Managed Inventory (Yao and Dresner 2008). The logic within these ARPs is often implemented directly into the company's ERP system or as an add-on to facilitate the replenishment process.

Essentially, the ARP calculates an order proposal for each item for each store based on certain transactional information from the stores, such as point of sales (POS) data, waste data and master data such as review periods and batch sizes. The order is a proposal which can be accepted or overruled by the store management (Van Donselaar et al. 2010). However, in either case it increases the transparency for the wholesaler and enables the wholesaler to compute an estimate for future (aggregated) orders.

More specifically, the ARP functions by sharing very fine data (high granularity per stock keeping unit (SKU) level with the wholesaler's data warehouse. At the wholesaler, the POS data is used to identify seasonal and other sales patterns and generates a forecast until next delivery (where the next delivery is determined based on the lead time and the ordering frequency). The sum of this forecast and the minimum inventory level becomes the order-up-to level for the store for those particular products. The minimum inventory level is included to create an appealing shopping experience by having a minimum number of facings of a giving product (Van Donselaar et al. 2010).

If the current inventory level at the store is below the order-up-to level an order proposal is generated by computing how many batches the store needs to raise the inventory level up or above the order-up-to level. The current inventory level at the stores might be an estimate based on previous amount delivered to the store, amount wasted and the POS data.

The elements for computation of the suggested replenishment quantity to the stores can be summarized as: i) ordering frequency ii) lead time iii) batch size iv) minimum inventory level v) POS data (to generate a forecast) and i) current inventory level (Van Donselaar et al. 2010).

Characteristics specific for the food sector such as shelf life and perishability is thus not included when the automatic replenishment program computes the replenishment quantity (Van Donselaar et al. 2006; Van Woensel et al. 2007). However, inventory policies which include these aspects have previously been proposed (Bakker, Riezebos, and Teunter 2012; Broekmeulen and van Donselaar 2009; Ferguson and Ketzenberg 2006).

2.1. The role of information sharing in automatic replenishment

A key element of ARPs is the use of an increased amount of shared information from the stores to enable better decision making (Yao and Dresner 2008; Lee, So, and Tang 2000). Information sharing is often listed as one of the key features for effective coordination and performance improvements in supply chain management (Arshinder, Kanda, and Deshmukh 2008; Ganesh, Raghunathan, and Rajendran 2014; Cooper, Lambert, and Pagh 1997; Kembro, Selviaridis, and Näslund 2014). Several studies have quantified the impact of information sharing by analytical and numerical calculations in a two level dyadic or divergent supply chain (Aviv 2001; Lee, So, and Tang 2000; Raghunathan 2001; Yu, Yan, and Edwin Cheng 2001; Cachon and Fisher 2000; Jonsson and Mattsson 2013; Gavirneni, Kapuscinski, and Tayur 1999) and with multiple echelons (Wu and Cheng 2008; Chen 1998; Ganesh, Raghunathan, and Rajendran 2014; Rached, Bahroun, and Campagne 2015).

Some studies indicate a high impact on performance by sharing information while others are more conservative due to particular contingency factors (Jonsson and Mattsson 2013; Ketzenberg et al. 2007). Borrowed from contingency theory (Donaldson 2006), the underlying idea is that certain factors influence the impact of information sharing (Kembro and Näslund 2014). Or in other words, how certain strategies of information sharing fits different circumstances (Vanpoucke, Boyer, and Vereecke 2009). Table 1 summarizes some of the typical factors found in the literature that moderates the impact of information sharing. However it should not be considered as an exhaustive list. Some of the factors still lack empirical evidence and the identification of other potential contingency factors is still an open research topic (Ketzenberg et al. 2007; Giard and Sali 2013; Kembro and Näslund 2014). Nevertheless, as ARPs are enabled by information sharing it is crucial to consider these factors when evaluating how ARP influences the performance of the company.

Table 1. Selected contingency factors which moderate the impact of information sharing

Factor	Explanation
Demand uncertainty	Intuitively, shared information should be used to reduce uncertainties as e.g. demand uncertainty. However, contradictory findings have been reported on this matter. Lee, So, and Tang (2000) observed that the impact of information sharing increases as the coefficient of variation (CoV) of demand increases while Chen (1998) and Ketzenberg et al. (2007) found the opposite conclusion.
Demand pattern	Jonsson and Mattsson (2013) and Gavirneni, Kapuscinski, and Tayur (1999) finds that the impact is dependent on the demand type (trend, seasonal, or promotional). E.g. sharing forecast has a higher impact than sharing POS data if demand is promotional.
Order quantity	Moinzadeh (2002) and Gavirneni, Kapuscinski, and Tayur (1999) found the highest impact of information sharing when the order quantity had moderate values compared to mean demand. If the order quantity is very large the supplier needs to start building inventory over time to accommodate demand. Thus, frequent insight into either customer demand or inventory level will only have a negligible influence on how production is planned at the supplier. On the other hand if the order quantity is very small orders are placed so frequently that the order itself provides sufficient information about customer demand and inventory level (Moinzadeh 2002; Gavirneni, Kapuscinski, and Tayur 1999).
Length of supply chain	The length of the supply chain can be understood as a combination of the number of echelons and the lead time between them. A general finding suggests that the impact of information sharing is higher for longer supply chains than shorter supply chains (Chen 1998; Lee, So, and Tang 2000; Moinzadeh 2002; Ganesh, Raghunathan, and Rajendran 2014; Jonsson and Mattsson 2013).
Substitution	Ganesh, Raghunathan, and Rajendran (2014) found that the demand pooling effect of product substitution decreases the impact of information sharing. i.e. if the effects of product substitution (demand pooling) is already included in the planning process, the additional impact of information sharing will be reduced especially further upstream in the supply chain.

2.2. Evaluating the impact on sustainability

Sustainability is often understood to consist of an economic, environmental and social dimension (Seuring and Müller 2008). However, we restrict our attention to evaluate the impact of ARP on food waste, remaining shelf life and availability and argue in the following why these are essential measures in food supply chains.

Firstly, in food supply chains food waste is often reported as the most important measure (Bourlakis et al. 2014; Gerbens-Leenes, Moll, and Uiterkamp 2003). A high level of food waste indicates that too many products were available, there is a loss in economic value and a waste of natural resources (Van Der Vorst 2006; Kummu et al. 2012).

Secondly, products should have a long remaining shelf life at the stores in order for consumers to buy them (Göbel et al. 2015). Longer remaining shelf life may be assumed to reduce food waste as consumers have more time to consume the products (Kaipia, Dukovska-Popovska, and Loikkanen 2013; Van der Vorst et al. 1998). Additionally, Little's law explains that if products reach the store with a longer remaining shelf life, the work in process inventory along the supply chain have been lower. Therefore, in food supply chains the remaining shelf life of products can act as a good proxy for work in progress inventory and clearly act as a measure for product quality (Van Der Vorst 2006).

Thirdly, high availability in stores is important to avoid lost sales. In practice product availability is prioritized above food waste by using high stock levels (Mena, Adenso-Diaz, and Yurt 2011) and is mostly measured at the warehouse and very rarely at the store (Aramyan et al. 2007). Therefore, a decrease in food waste at the stores and an increase in remaining shelf life is seen as an increase in performance, as availability most likely would not have been compromised.

3. Research design

The aim of this study is to empirically explore the impact of automatic replenishment programs on food waste metrics in a number of grocery stores in Norway. Based on the literature presented in Section 2, we expect to observe a lower level of food waste and a longer remaining shelf life as a result of replenishing through an ARP compared to manual replenishment.

We conduct a multiple case study approach with two cases – where the unit of analysis is the replenishment process (Yin 2013). Thus, one case where stores manually replenish products from the warehouse and one case where stores are replenishing products through an ARP. The case study method is particularly strong for in-depth exploration of new phenomenon and causal mechanisms (Yin 2013) and as such is an appropriate method for our study. Furthermore, the use of case study research enables us to study the phenomenon in its natural context and make good use of the existing experiences (Barratt, Choi, and Li 2011). Case studies are known for investigating past or current phenomena and draws on multiple sources of evidence, such as interviews, quantitative data and observations (Voss, Tsikriktsis, and Frohlich 2002). This allowed us to investigate transactional data and to assess the food waste levels and the remaining shelf life, as well as in-depth understanding of the context and how the cases differs and operates.

3.1 Data selection process

3.1.1 Retailer selection

The study involves a large Norwegian grocery retailer consisting of a warehouse unit and a unit of fully owned stores offering a full range grocery assortment consisting of dry, frozen and fresh food products. The retailer was selected for two main reasons: (1) they are using both manual replenishment and ARP among its own warehouses and stores – making it possible to establish and compare two cases within the same retailer (Voss, Tsikriktsis, and Frohlich 2002). The material and information flow of these two replenishment methods are outlined in Figure 1. (2) A high level of trust between the researchers and the retailer had already been established through previous and on-going research activities – making it possible to get access to rather sensitive data and use snowball sampling to connect with key personnel for interviews (Patton 2002).

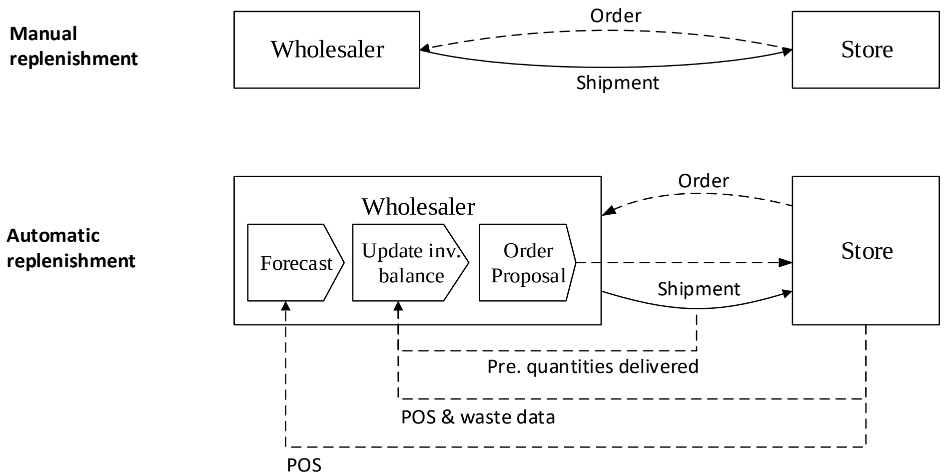

Figure 1. Flow of information and materials in the two replenishment methods

3.1.2 Case selection for investigating the impact on food waste

To compare the two replenishment methods it is essential that other factors that may influence food waste or remaining shelf life be kept constant in order to isolate the impact of the replenishment method. Table 1 presents several factors which have been identified to influence the impact of information sharing – as the ARP is enabled by information sharing these factors should be kept constant. Additionally, it has been reported that the *batch size* and the *ordering frequency* can influence food waste levels (Eriksson, Strid, and Hansson 2014; Van der Vorst et al. 1998; Chabada et al. 2015). Thus, the following selecting criteria were established to identify stores and products:

- The stores should be of the same size (physical size, opening hours, assortment, prices, campaigns, turnover and number of employees), thus experience similar demand uncertainty, demand type and substitution.
- Ordering frequency and lead time (time from ordered to delivered) should be the same to avoid influence on food waste
- Distance to the warehouse should be within one hour
- All stores have all products supplied from the same warehouse with the same batch size.
- A minimum of five stores should order the specific product with manual replenishment and a minimum of five stores with should order with the ARP i.e. a minimum 10 stores should carry the same product. These selection criteria were chosen to ensure that the data did not include any single extreme observations which may disturb the results.

We identified 21 stores and 54 products within those stores which fulfilled these criteria. One store may order some products manually and other products through an ARP, so it is not possible to completely place the stores in either the manual case or the case with ARP, this has to be done on a store product level. ie. if product A from store AA is ordered manually that particular observation (of sales, waste and shelf life) belongs to the manual case. By contrast, if product B from store BB is ordered through the ARP that observation belongs to the case with automatic replenishment. The characteristics of the two cases, i.e. the two replenishment methods are outlined in Table 2.

Table 2. Identical and different replenishment characteristics of the two cases

	Manual replenishment and ARP	
Ordering frequency	All products can be ordered 3 times per week	
Lead time	36-48 hours	
Availability	95-98% depending on the product group	
Stock rotation	Least shelf life first out	
Orders for promotions	Handled in a separate portal	
	Manual replenishment	**ARP**
Forecast	Qualitatively. Based on last week's sales and experience	Quantitatively. Based on 110 Weeks of POS data. Forecasting based on: SAP Forecasting & Replenishment module where the "best" method is selected automatically.
Inventory policy	(R,nQ) fixed review period (R); variable number of batch sizes (nQ)	(R,s,nQ) fixed review period (R); reorder point updated each review period (s); variable number of batch sizes (nQ)

3.1.3 Case selection for investigating the impact on availability and remaining shelf life

To take advantage of the case study method daily observations at two stores (out of the 21) were selected to record the remaining shelf life and availability of four products. The researchers visited these stores which also allowed for interviews with the personnel and mapping of the replenishment process. The stores and products were selected based on:

- Good reputation of the stores from the retailer (performance and willingness to collaborate)
- One store which mainly ordered with ARP and one that mainly used manual replenishment.
- Products from different product groups and with different length of shelf life to observe potential stock-outs or changes in remaining shelf life.

3.2 Data collection process

Total sales and waste data (SKU level) were collected for all 54 products for a nine month period, while the daily manual observations were conducted for a two week period. At each daily observation the inventory level including eventual stock-out situations and expiration date for the four products were recorded. Due to the time consuming nature of visiting each store every day this data collection was only possible for a limited number of stores for a two-week period.

Interviews were conducted both in the stores and at the warehouse. These interviews were conducted as semi-structured interviews to understand the identified elements from Section 2 (order frequency, lead time, forecast procedure, inventory policy, etc.) in regards to the two different replenishment processes. Insights into how the performance was perceived of the two replenishment methods were also obtained both at the warehouse and at the stores. Work experiences of the interviewees ranged from 2 years to 10+. Each interview lasted between 1-3 hours and was performed by a minimum two of the authors. Directly after the visit, the interview was documented in field notes and summarised by the researchers. Subsequently, it was sent to the company for approval and verification as well as discussed in small workshops which served as a platform for confirming and reconciling the interpretations. Table 3 summaries all collected data.

Table 3. Collected data

Type	**Description**	**Coverage**	**Purpose**
Data records	Sales of 54 products in 21 stores Waste of 54 products in 21 stores Shelf life of 54 products (master data)	Total sales and waste per product per store for nine months	Investigate the impact on food waste
Observations	Inventory level with remaining shelf life information of four products in two stores	Daily observations for 14 days	Investigate the impact on availability and remaining shelf life
Interviews (June 2015)	Store managers (2 pers.) Warehouse manager Employee responsible for ARP Employee responsible for forecasting	Between 1-3 hours per interview.	Understand the two replenishment methods and the perceived performance
Workshop (Sep. 2015)	Warehouse manager Store managers (2 pers.)	2 workshops, 2 hours each	Validate the collected data and discuss preliminary findings

3.3 Data analysis process

3.3.1 Impact on food waste

The data records of the 54 products (see Table 3) were grouped according to their shelf life as a higher food waste level was expected for products with short shelf life and less for products with long shelf life (Mena, Adenso-Diaz, and Yurt 2011). The groups (see Table 4) were formed based on the criteria of having the same range within each group (in this case ranges of 20 days) while at the same time not having too big a dispersion of the number of observations and number of products within each group. However, the first group (20 to 30 days) was used to separate products which in the literature are known as fresh food products with shelf life below 30 days (Van Donselaar et al. 2006). Due to confidentiality reasons any individual product cannot be presented with waste and sales information.

Table 4 specifies the number of data records for each group. The first group (20-30 days) consist of four products and with data from 21 stores a maximum of 84 data records in total is possible for this group. However, a total of 78 data records is included as all 21 stores did not carry all four products. Of the 78 records 29 is from stores with manual replenishment and 49 with an ARP.

The average waste percentage was calculated for each shelf life group for both replenishment methods. e.g. 49 records were used to calculate the average waste percentage for products that are ordered with ARP and have a shelf life of between 20 and 30 days.

Table 4. The number of products and data records for each shelf life group

Shelf life [days]	**Number of products**	**Typical products in this group**	**Data records**		
			Total	Manual	ARP
20-30	4	Eggs	78	29	49
31-50	13	Salmon, trout, cold cuts	225	106	119
51-70	16	Mayonnaise salads, fish cakes	270	111	159
71-90	9	Whole and sliced cheese	147	52	95
91-110	5	Butter, grated cheese	81	28	53
>110	7	Long-lasting bread and butter	133	43	90
Total	**54**		**934**	**369**	**565**

3.3.2 Impact on availability and remaining shelf life

The daily observations of the four products (see Table 3) were used to assess the on-shelf availability and calculate the average weighted remaining shelf life. The four products of minced meat, cold cuts, butter and grated cheese were selected to have products with a wide array of shelf life.

Table 5 illustrates the computations for average weighted remaining shelf life for the first day for grated cheese for replenishing with ARP. First, the remaining shelf life was extracted for each product based on the difference between the printed due date and the date the observation was made (e.g. days between 10.08.15 and 14.10.15 equals 65 days). Second, this was multiplied with the number of units with the same remaining shelf life (in this case 65 days x 55 units = 3575), and lastly the average was calculated by dividing with the total number of units.

Table 5. Calculation of average weighted remaining shelf life day 1 for grated cheese ordered with the ARP

Observation date: 10.08.15

Due date	(1) Remaining shelf life [days]	(2) Number of units	(1) x (2)
30.09.2015	51	1	51
14.10.2015	65	55	3575
27.10.2015	78	78	6084
Total		134	9710

Average weighted remaining shelf life = 9710 / 134 = 72.5 days

4. Analysis and results

The following two sections present the results from the quantitative data analysis together with findings from the interviews. The first section is devoted to analysis of the impact on food waste while the second section presents the findings related to availability and remaining shelf life.

4.1 The impact of ARP on food waste

Figure 2 illustrates the average food waste percentage for the six shelf life groups from Table 4. The collected data did not include any products with a shelf life below 20 days. The solid black line shows the food waste for products replenished manually while the gray line represents food waste for products replenished using ARP. Across all shelf life groups, the average food waste for products ordered manually is 7.3% compared to 6% for products ordered with ARP.

During the interviews, the responsible employees for the ARP and forecasting explained that an internal pilot study was conducted before rolling out ARP. During that pilot study it was observed products with a shelf life below 20 days should be kept for manual replenishment as it resulted in inadequate order proposals. This also explains why the collected data did not include any observations of products with shelf life below 20 days.

From Figure 2, we can make a general observation that, irrespective of the replenishment method, there is increasing food waste for products with a medium-long shelf life (between 51-110 days of shelf life). The group with the highest food waste consists primarily of different types of sliced and whole cheese. The two groups with lowest food waste, shelf life between 20-30 days and above 110 days are mainly eggs and breads with long shelf life. This is in line with the findings from (Eriksson, Strid, and Hansson 2014) who consecutively found a higher waste percentage for cheese than eggs.

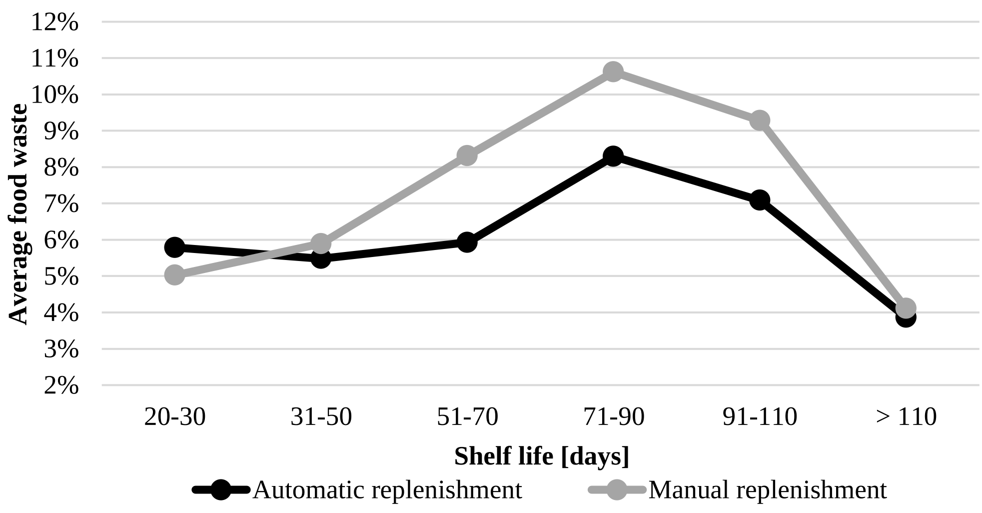

Figure 2. Food waste for a nine month period for ARP and manual replenishment

Secondly, reading figure 2 strictly, it indicates that ARP is favorable in all shelf life groups except for short shelf life products (below 30 days). More interestingly, the impact of ARP is biggest for those shelf life groups where the food waste is highest. There is a small improvement for product groups with shelf life between 31-50 days and above 110 days, however the improvement for products with shelf life between 51 and 110 days is a reduction of more than 20% (2% points) for these three groups. In other words, the impact of ARP appears to be dependent on product characteristics such as shelf life. The collected data was total sales for nine months and it was not possible to describe nor investigate the influence of other characteristics as e.g. demand patterns or demand uncertainty. However, as elaborated in table 1, other factors may influence the impact of information sharing and should be further investigated based on empirical insights.

4.2 The impact of ARP on availability and remaining shelf life

Figure 3 shows the average weighted remaining shelf life for the four products for the two different replenishment methods. The grey line represents products ordered manually while the black line represents products that are ordered with ARP. A clear tendency of a longer remaining shelf life, or better freshness, for products that are ordered with ARP can be observed. Across the four products, the remaining shelf life is 5.2% higher for products ordered with ARP compared to products ordered manually.

The difference between the two replenishment methods increases in a similar pattern to what was observed in Figure 2. i.e. for products with a medium-long shelf life (not *remaining* shelf life but the prescribed shelf life from production to expiration date, e.g. butter and grated cheese) the improvement is higher than for products with a short shelf life (e.g. cold cuts). For cold cuts, the improvement went from 30.8 days of remaining shelf life to 31.3 days of remaining shelf life, giving only a small increase of 1.6%. However, for grated cheese the remaining shelf life increased from an average of 66.8 days for manual replenishment to 71.5 days for replenishment with ARP giving a 7% improvement in remaining shelf life.

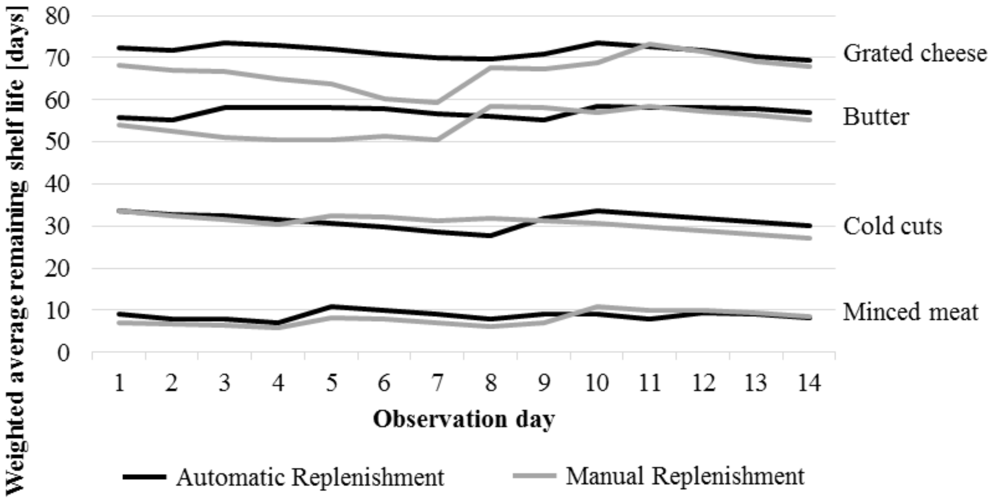

Figure 3. Average weighted remaining shelf life for replenishing with ARP and manual replenishment. Two week period with four products.

In the two week period of data collection the shelves were never observed to be empty and some products even had extra stock in the backroom of the store. This indicates a high level of availability for both replenishment methods. Additionally, it was noticed in the interviews that, based on the results from the retailer's own internal pilot study, stores with ARP experienced a

2-3% increase in availability (assuming that the stores had a yearly turnover of 1.2 million euro to ensure a satisfactory inventory turnover and stability for using ARP).

Also, from the interviews it was confirmed that for ARP to function it requires high quality data, e.g. it is important that the number of products on the shelves is aligned with the information in the system. Poor quality data would result is inadequate order proposals from the ARP. As a result, store managers have the option to overrule the order proposal from the ARP but this was mainly applied during the implementation phase until the ARP is fine turned.

Compared to manual replenishment the store managers explained that ARP required less experience and training and highlighted how this was apparent during sick leave and vacations where manual replenishment was challenging. The warehouse manager also added that using ARP makes the replenishment process more standardized. Ideally, this would result in a more consistent experience (related to availability and remaining shelf life) for the consumers across stores.

5. Discussion and conclusion

The aim of this study was to empirically explore the impact of automatic replenishment on food waste and remaining shelf life in a Norwegian grocery store chain. The study contrasted manual replenishment method with an automated one. The study demonstrated that the use of automatic replenishment has a positive impact on reducing food waste and increasing remaining shelf life of some food products. The improvement from automatic replenishment is highest for products with a shelf life between 51 and 110 days where the food waste reduction exceeds 20% (2% points) for the products analyzed. Unexpectedly, this group also represents the products with the highest food waste levels in the study. It was expected that the very fresh product category (shelf life below 30 days) had the largest waste levels as these products are highly time sensitive and are commonly known for having high food waste (Mena, Adenso-Diaz, and Yurt 2011; Kaipia, Dukovska-Popovska, and Loikkanen 2013). The waste level for the products with a long shelf life were low as expected, but it is somewhat interesting that the utilization of automatic replenishment did not seem to have a significant impact on food waste for this group.

The discussion of these results is separated into three main subsections. First, we discuss how the findings can extend the current body of knowledge of automatic replenishment and information sharing and how it affects sustainability measures. Afterwards we focus on the financial impact and place the findings in a managerial context to assess its implications. Lastly, we discuss the limitations of this study and propose important paths for future research.

5.1 Extension of literature

It has been proposed that increased information sharing of demand information upstream in the supply chain could contribute to decreased food waste in the supply chain (Mena et al. 2014). Also, empirical research establishing and investigating the relation between information sharing and performance is scarce (Baihaqi and Sohal 2013; Kembro and Näslund 2014). This study used an automatic replenishment program as a proxy for information sharing and investigated how it affects performance of certain sustainability measures.

We empirically investigated the relation between the use of automatic replenishment and food waste metrics in grocery stores. The findings suggest a positive relationship although modest in size. The impact may be as high as 20% for certain products, which can be used as an initiative for stores to engage in (more) information sharing activities. The findings add to the limited amount of literature which investigates how information sharing impacts food waste and the remaining shelf life. Similar to Kaipia, Dukovska-Popovska, and Loikkanen (2013) the findings show an improvement in both performance measures and supports proposition 1b by Mena et al. (2014).

Table 1 highlights how the impact of information sharing has been previously discussed to be dependent on certain contingency factors. If information is shared and used through an automatic replenishment program in a food context, Figure 2 and 3 suggests the impact of shared information depends on the shelf life of the product. The interesting question is why this dependency appears. A plausible explanation is that the POS and waste data do not provide sufficient information to support the complexity for replenishing products with a short shelf life. Here, additional information such as remaining shelf life, quality, appearance or an estimate of one of these might be necessary to share as well to improve the replenishment decision. This type of information is available with manual replenishment, thus there is a more complete picture of how the situation is, and could explain why it performs better for products with a shelf life between 20-30 days. When the shelf life is medium to medium-long (see Figure 3) it gets less complicated to make the replenishment decision and here POS data and waste data can be of great value for making replenishment decisions. For products with a long shelf life the replenishment decision might have little impact on the level of food waste and improving the replenishment decision for these products may therefore not show up as less food waste.

The dependency of shelf life for some products adds to the theoretical understanding of information sharing in supply chains. It has been proposed in numerous studies that the impact of information sharing is dependent on several factors, such as demand uncertainty, lead times and order quantities. However, this study proposes a new additional contingency factor by suggesting that, in a food context, the value of shared information is dependent on the shelf life of the products.

From a sustainability perspective, the findings indicate that the use of automatic replenishment contributes to a more sustainable food supply chain with less food waste and provides consumers with fresher products without harming availability. Obviously, reduced food waste is an economical gain for the companies involved in the chain, but reducing food waste at stores and improving remaining shelf life at consumers will, over time, require less food to be produced and transported from the primary producers to the final consumer. This contributes to a preservation of natural resources and limits the impact on the environment.

5.2 Managerial and financial implications

From a managerial perspective, the findings highlight that food waste is not only an issue for products with a shelf life below 30 days but also for products with medium to long shelf life. The use of an automatic replenishment program is a valuable remedy for decreasing food waste at stores for products with medium-long shelf life while maintaining the availability of products.

By using an automatic replenishment program the stores were able to obtain a 5.2% improvement in freshness and 1.3% lower food waste. An average reduction of food waste of 1.3% might not sound substantial and practitioners may find the impact too small to act upon. However, it should be taken into account that this is a net loss in profit for the individual store. If put into a broader context, namely the Norwegian grocery market, it becomes more interesting. The total profit in

2014, of the three largest grocery retailers in Norway, was 366 million Euro and a total turnover of 16,775 million Euro giving an average earning of 2.2%. If the 1.3% waste could be eliminated this would potentially increase the average earnings to 3,5%. In other words, an increase in profit with another 218 million Euro to a total of 584 million Euro in profit (some of the savings is of course already realized as some stores have implemented automatic replenishment). Additionally, savings for transportation, energy, water and cropland up through the supply chain is possible. Through better transparency the wholesaler would also be able to improve its own inventory performance (not just at the stores) an improvement that previously has been reported to be between 1.75% and 2.2% (Cachon and Fisher 2000; Chen 1998).

Overall, the results indicate that it is beneficial to utilize automatic replenishment for replenishment decisions in the food industry. However, some differentiating or tailoring of the replenishment system is needed for products with a short shelf life. Additionally, proper governance structures should be formulated for the ownership of the shared data, especially if the retailer and the wholesaler are two independent companies. If multiple retailers use the same wholesaler a neutral third party company could be introduced to receive the information and handle the automatic replenishment program. This will reduce the risk of competitors getting access to sensitive data.

5.3 Limitations and further research

The study has several limitations that should be used to guide further research. The study only includes a limited number of products for investigating the impact on availability and remaining shelf life in food stores in Norway. However, the small sample suggests that there is a possible improvement and for future research this should be scrutinized further with more products and a longer time period.

It has previously been highlighted how different demand patterns may influence the impact of information sharing. This could be further investigated for new empirical insights. The collected data in this study was the total sales for nine months and therefore a further analysis of demand patterns was not possible. Likewise, the data did not include products with a shelf life below 20 days. It should be investigate if sharing point-of-sales and waste data for these more perishable products are sufficient or if sharing more detailed information are needed and profitable to improve the replenishment decision (Huang, Li, and Ho 2015). This additional information may include inventory levels with remaining shelf life or estimated remaining shelf life based on temperature log (Ketzenberg, Bloemhof, and Gaukler 2015). This type information could not only be used for establishing more advanced inventory policies (Cannella, Ciancimino, and Framinan 2011; Cannella 2014; Costantino et al. 2015), but also used to make suggestions for highly relevant initiatives such as timely markdowns, shop by shop promotions or trans-shipments between nearby stores on the same delivery route.

Substitution among products may also be an important factor to consider for improving the replenishment decision further (Ganesh, Raghunathan, and Rajendran 2014). If the products are ordered manually, the manager may choose to order less of one specific product if he observes a high stock level of a substituting product with short remaining shelf life (in order to sell this first). The system that utilizes the shared information does not have this possibility and controls each product individually and will react more slowly to substitution signals. This is further supported by Van Woensel et al. (2007) who suggest that automatic replenishment for perishable items with short shelf life should be separate for non-perishable products and include the substitution effect.

6. Acknowledgements

The authors gratefully acknowledge the assistance provided by the Norwegian Research Council (NRC) for the financial support of Retail Supply Chain 2020. Also, we would like to thank the participating case company which together with the NRC enabled this study. We would like to thank Anita Romsdal, Jan Ola Strandhagen and Cecilia Haskins for their helpful comments and suggestions. Lastly, we would like to thank Chris Martin for assistance in editing this paper.

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Paper #4

Automatic replenishment of perishables in grocery retailing: The value of utilizing remaining shelf life information

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Purpose: To investigate the impact of sharing and utilizing remaining shelf life information from grocery stores by use of age-based replenishment policies for perishables
Design/methodology/approach: The performance is evaluated through a discrete event simulation model, which mirrors a part of one of Norway's largest grocery retailer and uses their POS-data to reflect a realistic demand pattern of 232 stores for one year
Findings: The findings indicate that a current age-based replenishment policy (EWA policy) provides a significant improvement of 17.7% increase in availability for perishables with a shelf life between 4 to 11 days, but suffers from high inventory levels and only reduces waste with 3.4% compared to a base stock policy. A newly proposed policy, EWA_{SS}, provides a more balanced performance with a reduction of 10.7% waste and 10.3% increase in availability by keeping the same average inventory level.
Implications: Sharing and utilizing remaining shelf life information for replenishment of perishables with a predetermined shelf life between 6 to 11 days can be beneficial, and could enable the replenishment processes to be automated. However, as the shelf life increases further the benefits slowly diminishes.
Originality/Value: The study proposes a new age-based replenishment policy which showed a more balanced performance improvement, in both waste and availability, compared previous replenishment policies.

Keywords. Information sharing, Shelf life, Replenishment, Perishables, Simulation

Submitted for first review: British Food Journal. October 2017

Role of the PhD candidate and declaration of authorship:
Kasper Kiil conceptualized the paper. All authors contributed to the design, verification, and validation of the simulation model. Kasper developed the simulation model, collected data, and performed the analysis. The paper was written with input from Hans-Henrik Hvolby and Kym Fraser.

Automatic replenishment of perishables in grocery retailing: The value of utilizing remaining shelf life information

1. Introduction

Perishables are of major importance for grocery retailers and accounts for 25% of the total sales and more than 35% of the growth in the European grocery market (Nielsen, 2016). Compared to other food products the main difference is the shorter shelf life (less than 30 days) (Van Donselaar et al., 2006). Food waste is often reported to be higher for these perishables products (Kaipia et al., 2013; Mena et al., 2014) and the short shelf life complicates the inventory management practice (Karaesmen et al., 2011). Non-perishable products are typically managed through an automatic replenishment system, which generates order proposals to the stores based on point-of-sales, safety stock levels, batch sizes, and delivering times (Potter and Disney, 2010). These systems have shown to improve performance of grocery retailer, however, they do not function satisfactorily in its original form for perishable products (Van Donselaar et al., 2006).

Suggestions for how automatic replenishment systems can handle perishable products has been introduced by utilizing remaining shelf life (RSL) information (also known as age distribution) of the products in the stores (Broekmeulen and van Donselaar, 2009; Duan and Liao, 2013; Lowalekar and Ravichandran, 2015). Mena et al. (2014) adds that increasing transparency (e.g. by sharing more detailed information about the product's age) might reduce supply chain wide food waste. This is also supported by the proposed replenishment models, which yields promising results with mean performance improvements (calculated as reduced cost) around 8% and up to 25% in some cases. However, several issues are still not addressed in the current solutions. Currently, the models are only tested with use of artificial generated stationary demand data in a dyadic relation with one warehouse and one store, or small scaled divergent systems. Likewise, the models only handle either a complete first-in-first-out (FIFO) depletion or complete last-in-first-out (LIFO) depletion even though reality lies somewhere in between those two (Janssen et al., 2016).

Even though the models can bring important insights they do not fully reflect a modern retailer configuration with hundreds of stores which each differ in sales, delivery frequency, and required service levels (Aastrup and Kotzab, 2010; Kuhn and Sternbeck, 2013; van Donk et al., 2008). It is further noticed that studies of information sharing in dyadic supply chains are too simplified and more realistic supply chain structures are encouraged (Huang et al., 2003).

The purpose of the paper is to investigate the impact of utilizing the remaining shelf life information from the stores in a setting closer to the reality of today's grocery retailers. Specifically, we do this by examining the inventory control of perishables in a divergent food supply chain based on one of Norway's largest retailers with more than 200 stores. Through simulation the study evaluates one of the popular heuristics for replenishment of perishables, the EWA policy (Broekmeulen and van Donselaar, 2009), and suggests and evaluates a refined version of this policy. The evaluation of the replenishment policies is made for products with a shelf life ranging from 4 to 20 days, mixed FIFO and LIFO depletion, various delivery frequencies, different service level requirements, and evaluated using an range of performance measures.

2. Background

In perishable inventory management demand is modelled either as deterministic or stochastic, and the shelf life is either considered as fixed or random. A fixed shelf life refers to a known deterministic life time whereas random shelf life refers to a known or unknown probabilistic life time (Janssen et al., 2016). In this study, focus is placed on modelling products with a fixed shelf life under stochastic demand. Within grocery retailing this includes products such as: dairy, meat, cold cuts, or other perishable products with a predetermined expiration date. Findings of how to manage these products with a fixed shelf life may later be extended to include products with a random shelf life.

If the shelf life of the product is fixed to one day the news vendor solution is optimal, and extensions for two days shelf life has also been provided (Nahmias and Pierskalla, 1973). However, as shelf life increases further it becomes significantly complicated to mathematically find the optimal solution and previous contributions has mainly searched for finding good heuristic replenishment policies rather than the true optimum (Broekmeulen and van Donselaar, 2009; Duan and Liao, 2013). Replenishment policies might be further subdivided intro either periodic or continuous review policies. Generally, continuous review policies need less safety stock than periodic review policies, but on the other hand require (hereof the name) a continuous review of the inventory level and the ability to place orders at all times (Silver et al., 1998). In grocery retailing periodic review is most common as stores have predefined days where they place and receive order (Kuhn and Sternbeck, 2013). Consequently, the remaining of this section is dedicated to present the most relevant periodic replenishment policies for perishables.

A (R,S)-policy with fixed life time is proposed by (Chiu, 1995) where the decision variables are both the length of the review period (R) and the order-up-to level (S). The flexible review period is beneficial from an inventory perspective, however, it might be impractical and challenging from a routing perspective. With only the order quantity as a decision variable Minner and Transchel (2010) proposed and evaluated a dynamic order policy, which showed a nearly 10% reduction in waste for products with a very short shelf life (less than 6 days) compared to constant order policy (i.e. fixed order quantity each time). Minner and Transchel (2010) further observed that, because of its simplicity, a constant order policy should not be neglected especially if demand is stationary, demand is somewhat stable (CoV □ 0.5) and the shelf life is short (2-3 days).

The EWA policy introduced by (Broekmeulen and van Donselaar, 2009) is a direct extension of the policy found in traditional automatic replenishment systems, and is intended to be used for automatic replenishment of perishables. Traditional automatic replenishment systems applies a (R,s,nQ) policy with a fixed review period (R), dynamic reorder-point (s), and order's a multiplier (n) of batches with a given batch size (Q) (Potter and Disney, 2010). In contrast, the EWA policy increases the order quantity based on the expected amount of products outdating. Compared to the dynamic policy by Minner and Transchel (2010) the EWA policy also takes into account the batch size constraint between the warehouse and the stores. Mathematically, the EWA policy can be expressed as follows:

$$if: I_t - \sum_{i=t+1}^{t+R+L-1} \hat{O}_i < \sum_{i=t+1}^{t+R+L} E[D] + SS \quad \text{then:}$$

$$Q_t = \left\lceil \frac{\sum_{i=t+1}^{t+R+L-1} \hat{O}_i + \sum_{i=t+1}^{t+R+Lt} E[D] + SS - I_t}{B} \right\rceil \tag{1}$$

Where:

It:	inventory position (inventory on hand plus inventory in transit) at time t.
R:	number of days until next review
L:	lead time
E[D]:	expected demand
SS:	safety stock, constant
B:	batch size (order multiplier between the store and the warehouse)
Qt:	order quantity (number of batches) ordered at time t
Ôi:	estimated amount of products outdating

The difference between the base stock policy and the EWA policy is the inclusion of an estimate for the amount of products outdating, Ô. If the inventory position, I, minus the expected amount of products outdating is less than the expected demand plus safety stock an order is placed. The order quantity is equal to the estimated amount outdating plus expected demand plus safety stock minus current inventory position, subjected to the batch size.

Another, but similar, approach is the old inventory ratio policy which determines the order quantity in a two-step procedure (Duan and Liao, 2013). First, the inventory position is raised following a base-stock policy. Second, if the ratio between the old (the assessment of when inventory is old is subjective) and the total inventory on hand exceeds a given threshold, □, an additional replenishment quantity – equal to the amount of old inventory – is ordered.

A simulation study, which evaluated six different replenishment policies found the EWA policy to be the best performing periodic review policy for perishables (Lowalekar and Ravichandran, 2015). However, as pointed out by Minner and Transchel (2010) the EWA policy applies a constant safety stock which might not by adequate if demand is non-stationary. Determining the right safety stock levels has been shown to be rather complicated and easily ends with an over supply (Van Donselaar and Broekmeulen, 2012). Based on the above studies the EWA policy is selected for this study, but to account for deficiencies in safety stock calculations a modification to the EWA policy is proposed in the following section.

3. Development of Modified EWA Policy

As observed by Van Donselaar and Broekmeulen (2012) the order quantity proposed by the EWA policy may be too high in some cases due to how safety stocks are included in the policy. Generally, for products with a short shelf life the EWA policy will place orders earlier than a base stock policy to account for the products that outdate. Consequently, if orders are placed earlier and the same safety stock levels are kept (as if a base stock policy was used) we risk having too many products with a limited RSL on inventory. This will result in a very high service level but also increase the risk of products outdating. As the predetermined shelf life of the product increases (say, above 15 days) the risk that products outdate on the shelf may decrease. And, as the number of products which outdate approaches zero, the EWA policy becomes equal to a normal base stock policy (Broekmeulen and van Donselaar, 2009). Therefore, to make a better balance and not just add to the order if there is a high number a products outdating it is proposed to slightly modify the EWA policy.

The difference between the EWA policy and the modified policy is in regards to the safety stock or total size of the buffer – hereof the name EWASS. In the EWA policy the total buffer size equals the amount of products outdating plus safety stock for demand certainty. In the EWASS policy this protection is shared. Thus, the total buffer size is either equal to the amount of products outdating, or the safety stock size based on uncertainty in demand (the biggest of the two). In other words, if the number of products outdating is e.g. 10 and the safety stock is 5, the EWASS policy will use a total buffer size of 10, whereas the total buffer size in the EWA policy would be 15. Mathematically it is formulated as:

$$if\ I_t - \sum_{i=t+1}^{t+R+L-1} \hat{O}_i < \sum_{i=t+1}^{t+R+L} E[D] + SS \quad \text{then:}$$

$$if\ SS < \sum_{i=t+1}^{t+R+L-1} \hat{O}_i \quad \text{then:}$$

$$Q_t = \left\lceil \frac{\sum_{i=t+1}^{t+R+L} E[D] + \sum_{i=t+1}^{t+R+L-1} \hat{O}_i - I_t}{B} \right\rceil \qquad (2a)$$

$$if\ SS \geq \sum_{i=t+1}^{t+R+L-1} \hat{O}_i \quad \text{then:}$$

$$Q_t = \left\lceil \frac{\sum_{i=t+1}^{t+R+L} E[D] + SS - I_t}{B} \right\rceil \qquad (2b)$$

The safety stock (SS) is calculated as the standard deviation of forecast errors during review interval plus replenishment lead time times a safety factor ($\sigma_{R+L} \cdot k$) (Silver et al., 1998).

4. Research Design

To investigate the performance of the EWA and EWASS policies in a more realistic setting than current literature the analysis in this study is based on a simulation model of a Norwegian grocery retailer. To estimate the impact of utilizing RSL information through these policies the simulation model mirrors the structure and settings (delivery times, service levels, review periods, etc.) and uses POS-data from 1 year to reflect sales pattern. Using simulation allows us to test various scenarios and investigate the causality between variables (Croom, 2009).

4.1. Case selection

The Norwegian retailer was selected due to ongoing research activities and a mutual curiosity in the topic. The retailer is currently considering the future degree of automation of the ordering process for various product types. Thus, they showed a high level of interest on the topic as well a high level of willingness to collaborate. This enabled the research team to get access to rather sensitive data and use snowball sampling to connect with key personnel for interviews (Patton, 2002). The retailer owns several warehouses and is in total supplying more than 1000 stores across Norway. For certain products the retailer uses cross-docking between its warehouses. Thus, to simplify and focus the problem one of the main warehouses and its accompanying 232 stores was selected for this study.

4.2. Data collection

Semi-structured interviews with the warehouse-, purchasing-, and logistics manager as well as the employees responsible for forecasting and the current automated replenishment system was conducted to understand the ordering process at both the stores and the warehouse. The outcome of these interviews were used for form the assumptions and logic of the simulation model. Additionally, daily POS-data from 232 stores for a one year period was received from the retailer to use for further analysis of the sales pattern.

4.3. Data analysis

The 232 stores belong to five different store concepts and each concept targets different market segments, which among others, is reflected through different requirements of service level. To account for the differences in weekly sales volume subgroups within each concept were formed (see Table 1). The number of subgroups were formed by balancing the dispersion in sales within the group (this should not be too high), and the number of stores within each group (the number of stores within each subgroup should be comparable) as well as accounting for the difference in delivery frequency. Hereby, the e.g. 69 stores belonging to concept A was divided into five subgroups (A-xs to A-xl) to reflect the diversity of sales among the stores and also account for differences in the number of weekly ordering days.

Table 1: Characterictic of subgroups (stores) in the simulation model

Concept	**Planned service level**	**Ordering days**	**Mean weekly sales (units)**	**Number of stores**	**Subgroup**
A	97%	Tu, Sa	16	11	A-xs
		Tu, Sa	25	11	A-s
		Tu, Th, Sa	34	22	A-m
		Tu, Th, Sa	49	17	A-l
		Tu, Th, Sa	62	8	A-xl
B	96%	Tu, Sa	5	12	B-xs
		Tu, Sa	8	23	B-s
		Tu, Sa	13	25	B-m
		Tu, Sa	18	17	B-l
		Tu, Sa	26	11	B-xl
		M, W, Sa	37	10	B-xxl
C	97,5%	M, W, Sa	30	3	C-xs
		M, W, Sa	46	9	C-s
		M, W, Sa	62	12	C-m
		M, Tu, W, Th, Sa	86	14	C-l
		M, Tu, W, Th, Sa	128	9	C-xl
D	98%	M, Tu, W, Th, Sa	74	4	D-s
		M, Tu, W, Th, Sa	108	6	D-m
		M, Tu, W, Th, Sa	172	2	D-l
E	97,5%	M, Tu, W, Th, Sa	222	3	E-m
		M, Tu, W, Th, Sa, Su	696	3	E-l

It is well-known that the sales pattern in retailing is different throughout the week (non-stationary) with higher sales towards the weekend (Aastrup and Kotzab, 2010; van Donk et al., 2008). Thus, for each subgroup a daily demand distribution was estimated based on the POS-data. I.e. for subgroup A-xs sales from all Mondays were plotted to fit a probability distribution and a total of (7 x 21) 147 probability distributions were fitted to mirror demand each day for each subgroup.

4.4. Model assumptions

The model is a discrete event simulation model, which includes the warehouse and 232 stores divided into the 21 subgroups from Table 1. The following notation and assumptions were used:

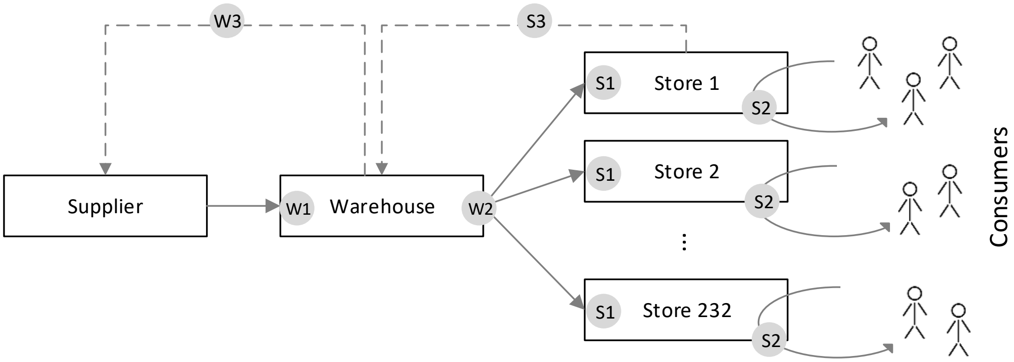
- The simulation model considers one product
- The model uses the fitted probability distributions to imitate demand at each store. A unique distribution for each day for each subgroup.
- The stores can place orders according to the ordering days listed in Table 1 as well as uses the listed service level
- Products arrive to the stores with a fixed lead-time of 38 hours. Upon arrival all products are placed on the shelfs with the newest products at the back of the shelf.
- Replenishment quantities for the stores are multiples of a batch size B.
- The safety stock, SS, is recalculated each time an order is placed according to the desired service level (from Table 1) and forecast error ($k \cdot \sigma\_RL$) (Silver et al., 1998).
- The warehouse can place orders at the supplier Sunday, Tuesday, Wednesday, and Friday
- Products arrive to the warehouse fixed lead-time of 38 hours, and to reflect the current situation at the Norwegian grocery retailer between 0-15% (uniform distribution) of the products they receive is one day old.
- Infinite supply is assumed from the supplier.
- Demand which cannot be satisfied is lost

The simulation model functions by a number of events at the warehouse (W) and at the stores (S). Figure 1 explains each event and how the relate to each other. At event S3 the EWA, EWASS and a baseline replenishment policies are implemented. The baseline is a reflects a traditional automatic system for non-perishable products (Potter and Disney, 2010). Besides the three events at the warehouse and the three events at the stores all products are reduced with 1 day of remaining shelf life for every 24 hours.

4.5. Model verification and validation

Verification refers to debugging of the simulation model and ensuring it functions as intended, while validation is concerned with determining whether the model is an adequate representation of reality (Kleijnen, 1995). For verification the tactic of ‘verification through intermediate calculations’ has been used, i.e. intermediate results in the simulation model (e.g. inventory level after receiving orders and satisfying demand) has first manually been calculated and then compared with the results from the simulation model (Kleijnen, 1995). If any discrepancies the model was corrected accordingly.

For validation purposes a direct comparison between the results from the simulation model and the performance in reality would have been favorable. However, because the selected grocery retailer does not have an automatic replenishment system for perishables implemented it was not found possible to make such a direct comparison. Instead, the results from the simulation model is compared with the results from the study by Minner and Transchel (2010). Their baseline scenario (same policy as ours) revealed 56.8%, 29.1%, and 2.8% waste depending on the shelf life of the product. For comparison, our result (with the same shelf life) is 63.9%, 33.9%, and 6.1%. The waste levels are not completely identical but comparable. The dissimilarities might arise from two differences in the models. First, the model by Minner and Transchel (2010) does not consider batch size constraints (as in our model). This is likely to explain the increased waste levels in our model (Eriksson et al., 2014). Secondly, the study by Minner and Transchel (2010) uses a lower service level (90%) requirement than in our simulation model (see Table 1), which also adds to discrepancies between the two models.



W1 Goods arrive and are added to inventory

To reflect the processing time and delivery time from the supplier goods are added to the inventory 38 hours after they are ordered.

W2 Satisfy demand

Orders from the stores are collected and shipped to the stores. In case of shortage a first-come-first-service principle is followed, and the FIFO principle is applied for stock depletion.

W3 Replenishment

If it is an ordering day an exponential smoothing forecast with weekly seasonality is generated covering the review and delivery time. It is assumed that the warehouse always has access to its own RSL information and the EWA_{SS} policy is always applied.

Night: Reduce RSL and record performance

All products with two day RSL is removed from inventory, and the RSL of all other products is reduced with one. Information about inventory level, average RSL, fill rate, and amount wasted is recorded.

S1 Goods arrive and are added to inventory

To reflect the processing time at the warehouse and delivery time from the Norwegian grocery retailer goods are added to the inventory 38 hours after they are ordered, e.g. an order placed Monday afternoon is added to the inventory Wednesday morning

S2 Satisfy demand

A random value is picked from the fitted probability distribution. The α value specifies how big a proportion of that demand that is depleted with FIFO (products with the lowest RSL at the front of the shelf) and the remaining part is issued with LIFO (products at the back of the shelf)

S3 Replenishment

If it is an ordering day for the particular store an exponential smoothing forecast with weekly seasonality is generated covering the review and delivery time. Depending on the selected replenishment policy the required number of batches are calculated and an order is placed.

Night: Reduce RSL and record performance

All products with one day RSL is removed from inventory, and the RSL of all other products is reduced with one. Information about inventory level, average RSL, fill rate, and amount waste is recorded.

Figure 1: Events in the simulation model

Numerical results

To evaluate the applicability and performance of the EWA and EWA_{SS} policy three main scenarios with different replenishment policies between the stores and the warehouse were established: (1) Baseline scenario, (2) EWA policy, and (3) EWA_{SS} policy. The simulations was run for one year (plus 4 months warm-up period for the forecasting procedure) and for each scenario the shelf life of the product was gradually increased (with 1 day) from 4 days of shelf life to 20 days of shelf life. These limits were made because the total lead time through the supply chain is at least 2 x 38 hours and products with a shelf life less than four days would have expired before they reached the stores. Additionally, no changes was observed with a shelf life above 20 days.

To make the simulations closer to reality a mix between FIFO and LIFO depletion was implemented. Specifically, 90 % of the demand in the stores was depleted following FIFO and the remaining 10 % following LIFO. These numbers were selected to symbolize that 90 % of the consumer will pick the products in front, while 10 % will search for products at the back of the shelf with a longer remaining shelf life. Additionally, a batch size between the warehouse and the stores of 9 SKUs to one batch was used. A sensitivity analysis of the FIFO depletion percentage and the batch size is include in the end.

To ensure a comprehensive evaluation of the scenarios relevant performance measures are selected. Several comprehensive performance measurement systems has been proposed for food and grocery supply chains encompassing various levels (supply chain, organization, process) and dimensions (e.g. availability, quality, cost) (Manikas and Terry, 2009; Van Der Vorst, 2006). Here, the most frequently used and recommend measures for grocery retailing is selected: availability (fill rate), waste, number of deliveries, and average inventory level (Broekmeulen and van Donselaar, 2009; Hübner et al., 2013; Kaipia et al., 2013; Van Der Vorst, 2006). The "moment of truth" for grocery retailers is when the consumers enter the stores and reach for the products on the shelves (Hübner et al., 2013). A low fill rate indicate a lack of supply to the stores while high waste might indicate an oversupply to the stores – thus, these two performance measures are useful to consider against each other. The number of deliveries are included to represent the transport and handling cost, while the average inventory level represents the tied-up capital.

In Figure 2 the fill rate and the waste is compared and the numbers refers to the shelf life, e.g. for the scenario with a product of eight days shelf life the baseline scenario resulted a fill rate of 88% with 23% waste.

From Figure 2 it can be observed that the EWA policy outperforms the two other policies in regards to fill rate when the shelf life is less than 11 days. This is expected as the total buffer size in the EWA policy is bigger than the EWASS. However, if the corresponding waste levels are considered it is observed that the EWA policy obtains the higher fill rate by wasting more products compared to the EWASS policy. Compared to the baseline scenario the EWA policy increases fill rate with 17.7% on average, and reduced waste with 3.4% for products with a shelf life between 4 and 11 days. In contrast, compared to the baseline scenario, the EWASS policy balances the increase in fill rate and decrease waste more evenly. Specifically, the fill rate increases on average with 10.3% and waste reduces with 10.7% for products with a shelf life between 4 and 11 days.

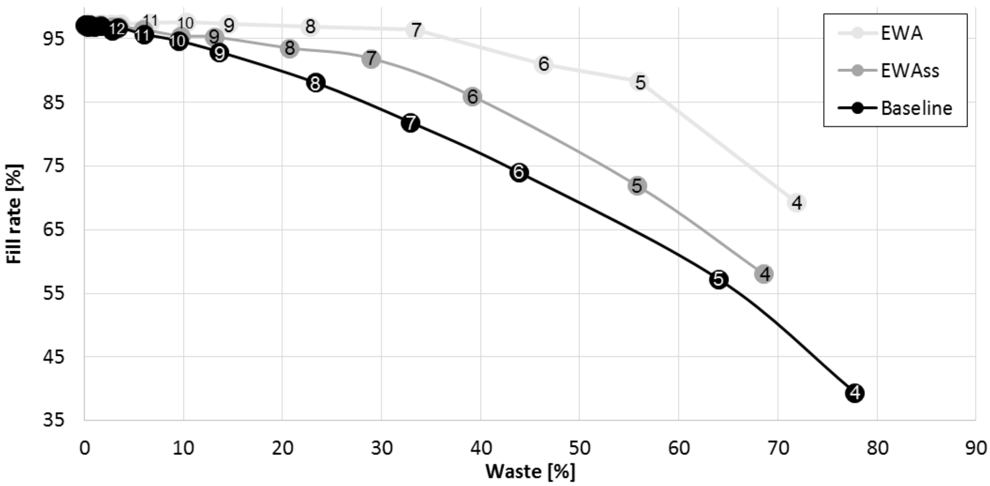


Figure 2: One year average waste across all stores and warehouse and fill rate across stores

Figure 3 depicts the number of deliveries to all 232 stores and the warehouse during the 1 year of simulation with the three different replenishment policies and with the products shelf life ranging from 4 to 20 days. The EWASS policy uses less deliveries than the EWA policy, and they both use more than the baseline scenario. This is coherent with the findings from Figure 2. If the fill rate have to improve the stores need to make use of more frequent deliveries, as the can not built inventory for e.g. a whole weeks sales as the will expire before the week is over. Thus, it is expected that the EWA and EWASS policy will have more deliveries than the baseline. On the other hand, the EWASS policy is able to align supply and demand more evenly than the EWA policy (higher fill rate and lower waste), which results in a lower number of deliveries. It could be argued that the EWA policy "oversupplies" the stores by constantly pushes new products out to the stores (due to the bigger buffer), which will require more deliveries and result in more waste compared to the EWASS policy.

For products with a shelf life between 4 and 11 days the EWA policies uses 28% more deliveries compared to the baseline scenario, whereas the EWASS policy uses 18% more deliveries. It should be noticed that in all scenarios the allowed number of ordering days follows the specifications from Table 1. Thus, the differences is simply because the stores (i.e. the replenishment policy) did not make use of all allowed ordering days in the baseline scenario. Also, in a practical context the stores in e.g. subgroup a-x would place orders both Tuesday and Saturday for their entire product range, but not necessarily place an order for this particular product. Therefore, a high number of deliveries does not necessarily require more physical transportation, merely, an increased amount of activities at the warehouse for picking and packing products and the stores for restocking the shelves (Kotzab and Teller, 2005).

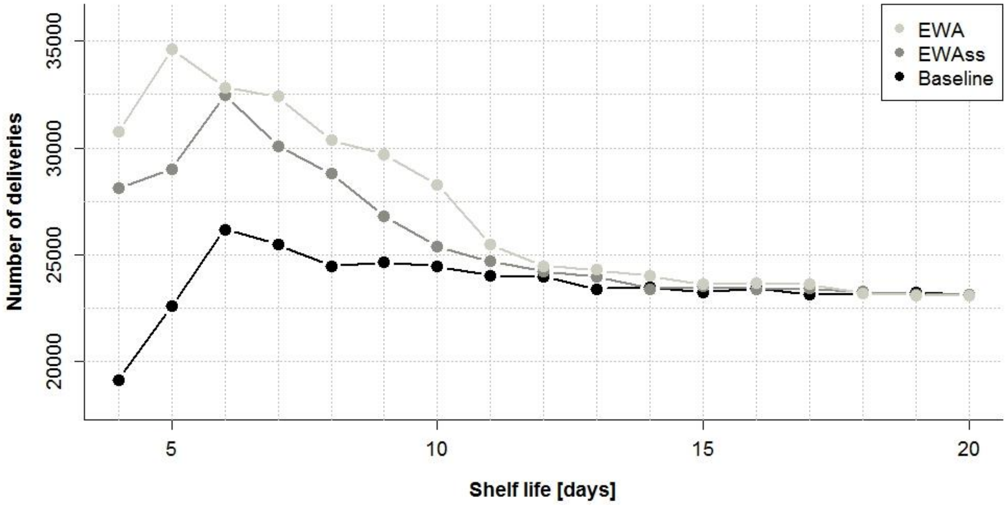


Figure 33: Total number of deliveries for one year for all stores and warehouse

Compared to the EWA policy, an improved alignment of supply and demand with the EWA_{SS} policy is also reflected by a lower average inventory level as shown in Figure4. The EWA policy pushes more products to the stores and creates a higher inventory level compared to the EWA_{SS} policy and baseline scenario. For products with a shelf life between 4 to 11 days the average inventory level is 17.8% (1307 units) higher for the EWA policy compared to the baseline scenario. This obviously requires more capital to be tied up in inventory. For comparison, the EWA_{SS} policy has an average inventory level which is -0.3% lower than the baseline scenario.

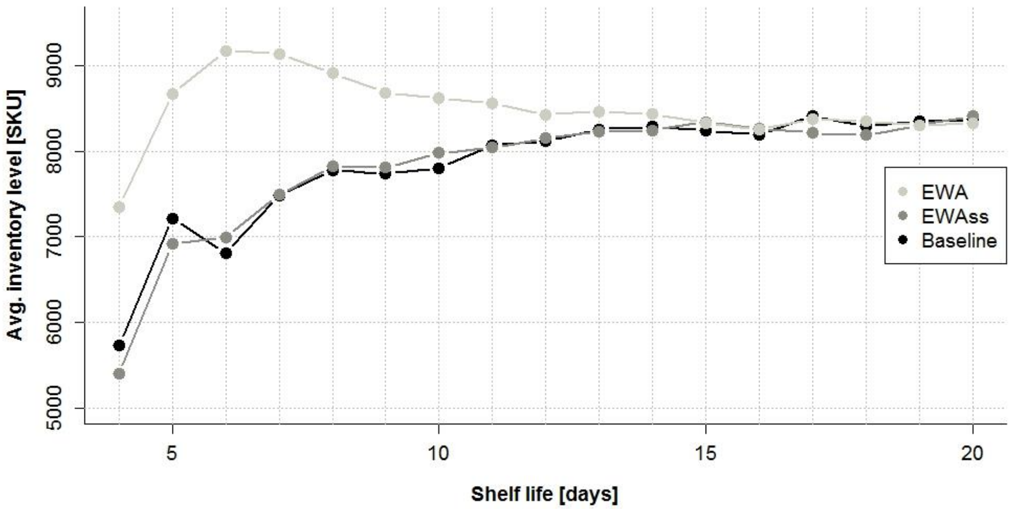


Figure 4: Average inventory level for one year across all stores and warehouse

To evaluate the robustness of the results two sensitivity analyses were made. First, all three scenarios were run with an 80% and 100% FIFO depletion in the stores. The results showed that all performance measures were similar, and only a 0.3% point reduction in waste was observed as the depletion decreased to 80%. In the second sensitivity analysis all three scenarios were run with a batch size of 6 and 12. Not surprisingly the results indicates that lower batch sizes results in lower inventory levels and increased deliveries. A smaller batch size also slightly reduces waste, with approximately 0.7% point for both the EWASS policy and 0.8% EWA policy, which is coherent with previous findings (Eriksson et al., 2014).

6. Discussion and conclusion

The purpose of this paper was to investigate the impact of utilizing remaining shelf life information from stores for the replenishment in a setting that was closer to reality than previous reported in academic literature. Through a discrete event simulation model with one warehouse, one product, 232 stores, mixed FIFO and LIFO depletion, differentiated service levels and ordering frequencies, as well as batch size constraint two age-based replenishment policies were evaluated based on one year POS-data from one of Norway's largest grocery retailer. If remaining shelf life information is utilized in the replenishment decision the findings indicate a potential improvement in availability (up to 15.5% increase) and waste (up 2.3% reduction) for products with a shelf of 10 days or below. The remaining discussion and conclusion is centered around three subsections: theoretical contributions, practical implications, and limitation and future research.

6.1. Contributions to theory

This study makes two primary contributions to theory. Firstly, the EWA policy by Broekmeulen and van Donselaar (2009) has been evaluated in a divergent supply chain. The results indicate an average increase of 17.7% in fill rate, for products with a shelf life between 4 to 11 days across all 232 stores. Even though the fill rate is not reported separately this increase is similar to the cost improvement reported by Broekmeulen and van Donselaar (2009). However, the findings also shows that the EWA policy suffers from high inventory and only reduces waste levels slightly, which could be caused by too high buffers for demand uncertainty and the risk of expiration (Van Donselaar and Broekmeulen, 2012). Secondly, to off-set the high waste levels and high inventory levels a modification to the EWA policy, EWA_{SS}, is proposed and evaluated. The EWA_{SS} policy demonstrates a more balanced performance of fill rate (+10.3%) and waste (-10.7%) by improving both parameters without affecting the average inventory level.

6.2. Implications for practitioners

The findings from Figure 2 to Figure 4 clearly demonstrates that the value of sharing and utilizing information is dependent of the shelf life of the product. Thus, for practitioners the findings indicate that differentiated information sharing and replenishment policies are useful for managing a broad range of products. The shelf life is an important characteristic for establishing this differentiation, and for perishables the remaining shelf life information from the store can be beneficial to utilize – especially for products with a shelf life around 6 to 11 days based on Figure. On the other hand, as the shelf life increase, using only POS and waste data (how many product that are wasted each day) provide a satisfactory performance.

Even though the findings show an improvement in performance grocery retailers and need to evaluate if they can accept the (still high) waste levels. If so, the findings indicate that it will be possible to automate the replenishment process for perishable products by utilizing remaining shelf life information. Additional initiatives could also be combined with a sophisticated replenishment policies and information sharing. E.g. using cross-docking will reduce the time spent on the warehouse and move products faster to the store, or reducing the batch size to avoid too many products being wasting at small stores with a low turnover.

6.3. Limitations and future research

The study has several limitations and should be used to guide future research. The study only included one product and should be extended to (at least) a whole product group. Hereby the effects of product substitution could be included and incorporated into the replenishment decision as well (Van Donselaar et al., 2006). The use of simulation provides a risk-free environment to assess different scenarios and could be particular relevant to evaluate age-based replenishment polices with substitution. However, empirical research with access to real performance data are encourages to account for the various uncertainties and particularities that are not included in a simulation model.

Both the EWA and the EWA_{SS} policy assumes that remaining shelf life information is collected and shared from the grocery stores. Future research could investigate if it would be possible to estimate this type of information based on (1) the remaining shelf life when the products leave the warehouse, (2) the amount of products wasted and sold each day in the stores, and (3) estimates of the FIFO depletion rate in the stores. If reasonable estimates are possible the EWA and EWA_{SS} policy could be implemented without investments for additional data collection.

Acknowledgement

The authors gratefully acknowledge the assistance provided by the Norwegian Research Council (NRC) for the financial support of Retail Supply Chain 2020. Also, we thank the participating case company which together with the NRC enabled this study

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Paper #5

Inventory allocation of perishables: Guidelines

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Abstract. The purpose of this study is to investigate and propose guidelines for how to allocate perishables to improve the balance of freshness and availability in retail stores. Specifically, it is investigated how a single warehouse can make the allocation decision to stores with and without access to remaining shelf life information of the products in the stores. Contrary to complex decisions models, this study aim to develop simple guidelines that can be applied manually or easily integrated into existing decision support systems.

Keywords: Inventory allocation, Food supply chain, Perishables, Information sharing, Remaining shelf life

Published: Advances in Production Management Systems: The Path to Intelligent, Collaborative and Sustainable Manufacturing. 3-7 September 2017, Hamburg, Germany

Role of the PhD candidate and declaration of authorship:

Kasper Kiil conceptualized the paper and the development of the guidelines together with Hans-Henrik Hvolby. The first version of the paper was written by Kasper and afterwards continuously improved by all authors. Kasper presented the paper at the conference in Germany 2017.

Inventory allocation of perishables: Guidelines

1. Introduction

Food supply chains separates itself from other supply chains and necessitates special logistical requirements due its characteristics of perishability of products, high demands on quality, and tractability requirements [1, 2]. Particularly, for products with a shelf life less than 30 days – known as perishables [3, 4] – where the quality of the products deteriorate over time, questions the applicability of non-perishable supply chain practices in food supply chains [5, 6].

In retail supply chains, stores in a particular geographical region may be supplied from a central warehouse or a smaller distribution centre. Inventory allocation policies consider how to distribute products among the requesting stores from the warehouse in case of shortage – also known as rationing policies [7, 8]. For perishables, this decision is further complicated as the products to allocate may have different remaining shelf life. Even if the warehouse has more stock on hand than what is requested from the stores (no rationing required) the products still needs to be allocated among the stores to reduce the risk of outdating. Consequently, it has been stated that for perishables the *age* of the allocated products may be as important as the *amount* allocated [9].

Rationing policies consider how to distribute the *amount* of products from the warehouse typically based on information about expected demand, inventory position, or safety stock levels at the stores [7]. The different *age* groups of products at the warehouse can be expressed by the remaining shelf life (RSL_W) of those products. To decide which stores that should receive products with the longest RSL_W the remaining shelf life of the products currently at the stores (RSL_S) appear useful and will be investigated. Hereby, a more even distribution of freshness across the supply chain may be obtained.

The literature on allocation of perishables in distribution systems is limited [10] and is often presented as comprehensive decision models [11, 12]. It has been noticed that advanced models and decision support systems faces some barriers of implementation (e.g. the underlying model is too complex and not understood nor trusted [13]). Subsequently, there is a need to investigate more real world settings of perishables [14].

In this study, we investigate and propose simple guidelines for how practitioners can allocate the amount and the age of perishables. As the allocation of the products is made at the warehouse, we assume access to RSL_W at all times. However, depending on the level of shared information the warehouse might not have access to the RSL_S. Thus, we investigate and propose guidelines for the following scenarios:

(1a) The warehouse has not access to RSL_S and no shortage at the warehouse
(1b) The warehouse has not access to RSL_S and shortage at the warehouse
(2a) The warehouse has access to RSL_S and no shortage at the warehouse
(2b) The warehouse has access to RSL_S and shortage at the warehouse.

The remainder of this paper is organized as follows: first, we present the relevant literature about rationing and inventory allocation of perishables. Afterwards, we restrict our attention to the development of the guidelines. Section four discusses the implications and applicability of the guidelines.

2. Background

For non-perishables the optimal control of divergent distribution systems follows the order-up-to policy under the balanced stock assumption [9]. The balanced stock assumption assumes that the inventory position across all downstream stocking points are balanced or at least negligible unbalanced, making it possible to consider a divergent system as a serial system [15]. For divergent systems typical rationing policies includes: *Fair Share* allocation which strives to obtain an even probability of stock-out at each downstream stocking point [7]. *Priority* allocation which ranks and allocate the amount available based on the importance of each customer. *Consistent Appropriate Share* allocation where downstream stocking points with higher safety stock receives a bigger ratio from the warehouse [7].

No equivalent optimal control mechanism exists for perishables in divergent systems due to the complexity created by the different ages of the products [9]. Divergent systems are of special interest as these reflects the common situation of food supply chains. Yet, the contributions for controlling perishables are limited in these systems [10]. Two main classes of policies can be identified: (1) rotation policies, where the remaining inventory from downstream stocking points is returned to the warehouse at the end of each period, and (2) retention policies where the downstream stocking points keeps all remaining inventory until sold or outdated [16]. As it is most common to apply the retention policy in food supply chains we restrict our attention to these.

Traditionally, the allocation decisions for perishables have been simplified to reduce complexity [9]. For instance assuming zero lead time [17] or infinite supply to the stores [10]. Also, in the policy by Prastacos [16] the only products of interest are products that outdate at the end of the next period, or in other words, only products with one day left of shelf life. Because it is assumed that the warehouse has a constant flow of products to the stores, the warehouse will never keep products with a remaining shelf life of one day. Hereof it follows that what the warehouse allocates to the stores do not influence outdating in the end of next period (the products that outdates are already in the stores), and the problem is reduced to minimize the risk of shortage.

To minimize shortage and outdating a common observation appear to have been found in literature: (1) the number of products soon-to-outdate should be distributed evenly and relatively to demand (for each location), and (2) the total amount allocated should equalize the probability of stock-out at each location [10, 16].

3. Development of guidelines

If the RSL_S are unbalanced among downstream stocking points it might not be sufficient to *just* focus on the soon-to-outdate products at the warehouse, and allocate them relatively to demand as suggested above. Three practical obstacles highlights this. Firstly, that allocation procedure do not consider how to allocate products which are not classified as "soon-to-outdate" and how this affect the freshness at the stores. Secondly, in food supply chain products are often shipped in multiplies of batch sizes [3], and the allocation sizes might end up being different from the number of batches – meaning the soon-to-outdate products cannot be evenly distributed. Thirdly, from the perspective of the pick-and-pack process it is more efficient if e.g. three batches from the same pallet (same RSL_W) is collected to one order instead of three batches from three different pallets.

Step 1 - Calculate the average supply chain wide service level:

Assuming a perfect balanced distribution of available products among the stores, we calculate the ratio between available products ($\Sigma I_i + I_0$) in the chain and the total demand across ($\Sigma BQ_i + \Sigma I_i$) the whole chain – giving an indication of the best case service level. Again, demand is considered as the sum of orders and current inventory levels from the stores.

$$SLA1_{SC} = \frac{\sum I_i + BI_0}{\sum BQ_i + \sum I_i} \text{; for all } i \qquad (2)$$

Similar, for each store the current service level can be calculated:

$$SL1_i = \frac{I_i}{I_i + BQ_i} \qquad (3)$$

Continuing the example from above, and with 3 batches available at the warehouse (I_0) it can be calculated that $SLA1_{SC}$ is (40+20+10*3)/(10*2+10*2+20+40) = 90%. $SL1_A$ equals 20/(20+10*2) = 50% and $SL1_B$ 40/(40+10*2) = 66.67%.

Step 2 - Calculate the possible supply chain wide service level:

Stores which has a current service level ($SL1_i$) larger than average supply chain wide service level ($SLA1_{SC}$) is "overstocked", and should ideally receive negative quantities in order to distribute their surplus among "understocked" locations [7, 16]. However, as these types of transshipments is very uncommon food supply chains, we propose to exclude the overstocked locations and only distribute the available products from the warehouse to understocked locations by calculating a new supply chain wide service level:

$$SLP1_{SC} = \frac{\sum I_i + BI_0}{\sum BQ_i + \sum I_i} \text{; for all } i \text{ where: } SL1_i < SLA1_{SC} \qquad (4)$$

From the example, as both $SL1_A$ and $SL1_B$ is less than $SLA1_{SC}$ both stores are understocked and $SLP1_{SC}$ will in this case be equal to $SLA1_{SC}$.

Step 3 – Calculate allocation quantities:

$SLP1_{sc}$ specifies the service level at each store after allocation, thus the allocation quantity can easily be determined by subtracting the current inventory level (I_i):

$$QA1_i = \frac{(I_i + BQ_i)SLP_{SC} - I_i}{B} \text{; for all } i \text{ where: } SL1_i < SLA1_{SC} \qquad (5)$$

$QA1_A$ would equal ((20+10*2)*90%-20)/10 = 1.6 and $QA1_B$ = 1.4. Hence, store A would receive 2 batches and store B 1 batch. Lastly, the stores are again ranked following $Rank_1$ to allocate RSL_W. Stores B will have the highest score and receives the oldest products.

3.2 Allocation of perishables with RSL_S information

3.2.1 Inventory greater than demand

As in section 3.1 when inventory is greater than demand the issue is reduced to how to allocate the different age groups from the warehouse to the requesting stores. With access to RSL_S

information both the number of products soon-to-outdate (A) and the weighted average remaining shelf life of that amount (WA) can be calculated and used to improve the allocation. To compensate for either a high amount of products (A) or a low RSL_S (WA) for improving the allocation the ratio between those two are calculated:

$$RA_i = \frac{A_i}{WA_i} \text{; for all } i \tag{6}$$

This ratio may be used as a measure for comparing stores against each other – a smaller ratio indicates a smaller risk of products outdating. E.g. assume store A has 4 products soon-to-outdate with a weighted average RSL_S of 2 days (RA_i=4/2=2) compared to the bigger risk at store B with 15 products with a weighted average RSL_S of 2 days (RA_i=15/2=7.5).

However, this risk should be considered in relation to the expected sales of the two stores. As previously, stores with higher expected sales are expected to have a higher chance of selling products before the expire and should receive the oldest products from the warehouse. The risk of products outdating (RA_i) is compared to the expected sales:

$$Rank_2 = \frac{RA_i}{BQ_i + I_i} \tag{7}$$

Store A equals 2/(2*10+20) = 0.05 on $Rank_2$ while store B ranks with 7.5/(10*2+40) = 0.125 meaning that, proportionally to demand, store B has a higher risk that the products already in the store will outdate. Thus, store A (with the lowest $Rank_2$ value) receive the oldest product and store B receive the newest. Hereby, a more even distribution of freshness will be obtained across the chain.

3.2.2 Inventory less than demand

In case of shortage at the warehouse a similar procedure is followed as without RSL_S information - the difference is stores, which either has many products soon-to-outdate (A) or little RSL_S left (WA) which gets more weight relative to other stores. We use the RA ratio to make this comparison. A high value indicates that the store risks some products to outdate, thus it can be considered as an "extra demand" to be covered by the store. We adjust the steps and formula 2-5 accordingly:

Step 1 - Calculate the average supply chain wide service level:

$$SLA2_{SC} = \frac{\sum I_i + BI_0}{\sum BQ_i + \sum I_i + \sum RA_i} \text{; for all } i \tag{8}$$

$$SL2_i = \frac{I_i}{I_i + BQ_i + RA_i} \tag{9}$$

Assuming 3 batches on the warehouse, $SLA2_{SC}$ can be calculated to (20+40+10*3)/(10*2+10*2+20+40+2+7.5) = 82.2%, $SL2_A$ to 20/(20+10*2+2) = 47.6% and $SL2_B$ to 59.2%.

Step 2 - Calculate the possible supply chain wide service level:

$$SLP2_{SC} = \frac{\sum I_i + BI_0}{\sum BQ_i + \sum I_i + \sum RA_i} \text{; for all } i \text{ where: } SL2_i < SLA2_{SC} \tag{10}$$

As both $SL2_A$ and $SL2_B$ is less than $SLA2_{SC}$ both stores are understocked and $SLP2_{SC}$ will in this case be equal to $SLA2_{SC}$.

Similar to literature about simple replenishment policies of perishables (see e.g. [4, 18], we aim to develop simple allocation policies for perishables which acts as guidelines to ensure its applicability. These guidelines should consider and accommodate the obstacles highlighted above.

The following section presents the guidelines if RSL_S information from the stores are not available to the warehouse, and the second section presents the guidelines if we assume RSL_S is available. All guidelines assumes there is access to RSL_W at all times. Some general notation is outlined below:

B :	Batch size (order multiplier between the store and the warehouse)
Q_i :	Order quantity (in batches) from store *i*
I_i :	Current inventory level at store *i* (in SKUs)
I_0 :	Current inventory level at warehouse (in batches)
L_i :	Lead time for store *i*
R_i :	Days till next review at store *i*
A_i :	Amount of "old" products at store *i* whit a RSL_S less than or equal to R+L
WA_i:	Weighted average RSL_S of A_i at store *i*

3.1 Allocation of perishables without RSL_S information

3.1.1 Inventory greater than demand

Rationing among stores are not necessary when the warehouse holds more inventory on hand than what is totally requested from the stores. This reduces the problem to how to allocate the different ages groups from the warehouse. To counteract the obstacles of batches and how to distribute different RSL_W to the requesting stores, we propose to rank stores according to expected sales until next delivery – stores with the highest expected sales receive the oldest products from the warehouse to increase the chance of selling these products before they outdate. The expected sales until next delivery (L_i + R_i) includes the order (Q_i) plus the current inventory level at the store (I_i), mathematically we formulate this ranking as:

$$Rank_1 = \frac{BQ_i+I_i}{L_i+R_i} \tag{1}$$

As an example, assume store A has 20 products currently on inventory (I_i) and ordered (Q_i) additionally 2 batches of 10 products, while store B has 40 products on inventory and also ordered additionally 2 batches. With both stores having a review and lead time (L_i+R_i) of totally 2 days, store A would obtain a $Rank_1$ score on (2*10+20)/2 = 20 and store B (2*10+40)/2 = 30. In this case store B should receive the oldest RSL_W as a higher sales is expected here compared to store A.

3.1.2 Inventory less than demand

If the warehouse holds less inventory than what is totally requested from the stores, rationing among the requesting stores are necessary. Thus, it is necessary to allocate the available amount and the different age groups from the warehouse. We propose a three-step procedure following the logic from the fair share allocation rule to calculate the amount to allocate.

Step 3 – Calculate allocation quantities:

$$QA2_i = \frac{(I_i + BQ_i + RA_i)SLP2_{SC} - I_i}{B}; \text{ for all } i \text{ where: } SL2_i < SLA2_{SC} \qquad (11)$$

$QA2_A$ would equal ((20+10*2+2)*82.2%-20)/10 = 1.45 and $QA2_B$ = 1.55. Hence, store A would receive 1 batches and store B 2 batches. Lastly, the stores are again ranked according to $Rank_2$. Stores A will have the lowest score and will receive the oldest products.

4. Conclusions

This study adds to the limited literature about allocation of perishables [10] by proposing guidelines for how practitioners can allocate perishables to improve the balance of freshness and availability in stores. Two main areas of concern is discussed in this section. Firstly, what is the implications[2] of applying guidelines like these in practice? Secondly, how widespread is the applicability and the ease of implementation?

The guidelines strive to balance the risk of shortage and outdating evenly across all downstream stocking points while accommodating practical obstacles like batch sizing and the efficiency of pick-and-pack process. $Rank_1$ is applied when there is no access to RSL_S information, and strives to ensure smaller stores with less sales receive products with the highest RSL. Often smaller stores only have deliveries few times a week, thus it is essential that the products they receive last as long as possible. On the contrary, bigger stores with higher sales will receive the less fresh products. The chances of a consumer willing to accept a lower RSL might be higher in these stores as they generally has more consumers through the store during the day. $Rank_2$ can be applied when the warehouse has access to the RSL_S information. It basically follows the same reasoning about fresher products to smaller stores. But, here the allocation (amount and RSL) are dynamically adjusted according to the RSL_S. Hereby, larger stores do not necessarily always get the products with lowest RSL.

Even though the guidelines can be considered applicable to most food supply chains, there is risk that some stores perceive themselves as having a lower priority if they continuously receive products with lower RSL than other stores. This should be considered, especially if the stores are independently owned or franchising of a larger retail concept. The benefits should be distributed to ensure those stores that may take a big risk of receiving products with low RSL also receive a corresponding reward. On the other hand, stores that are fully owned by the same retailer may prefer guidelines as these proposed in this study to improve the balance of freshness and availability across all its stores.

Lastly, it should be noticed, that using guidelines like these do not guarantee an optimum balance of freshness and availability and could be considered as a limitation – however, they provide an easier reasoning for the employees who has to apply them. As future research the guidelines should be tested either through simulation experiments or case implementation to quantify the impact on freshness and availability.

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2 The guidelines will be tested through discrete event simulation to estimate the impact on freshness, waste, and available. The results will be presented at the APMS conference in Hamburg 2017 and will be available upon request, but is omitted in the paper due to space limitation.

5. Acknowledgements

We gratefully acknowledge the assistance provided by the Norwegian Research Council for the financial support of Retail Supply Chain 2020 that enabled this study.

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Paper #6

Retail Tactical Planning: An Aligned Process?

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Abstract. This paper addresses tactical planning in retailing through a case study approach in one grocery retailing company. Specifically, the issues are how tactical planning is conducted and how the different plans are connected and interact. The case study complements earlier retail planning studies by showing the sequence of planning phases and by studying the fragmented plans as a process. We found that the master category planning phase is important and sets borders for the other planning phases. This practice stabilizes overall planning and is an efficient solution in a complex grocery retailing environment. However, by obeying this practice, the retailer loses responsiveness to demand. Based on the study results, better integration among planning phases is proposed. The company could, if better demand responsiveness is desired, implement formal practices to enable reactions to changes in the environment, particularly demand. These practices could include feedback loops from execution to tactical planning to enable, if needed, plan and planning parameter changes.

Keywords: retailing, grocery, planning processes, tactical planning, demand responsiveness.

Published: Advances in Production Management Systems: Production Management Initiatives for a Sustainable World. 3-7 September 2016, Iguassu Falls, Brazil.

Role of the PhD candidate and declaration of authorship:

Heidi Carin Dreyer conceptualized the paper. Data collection was jointly performed by Heidi and Kasper Kiil, while the data analysis was conducted by Heidi, Kasper, and Iskra Dukovska-Popovska. All authors contributed to writing the paper. Kasper presented the paper at the conference in Brazil 2016.

Retail Tactical Planning: An Aligned Process?

1. Introduction

Efficient supply and demand planning is an appropriate solution to ensure product availability in stores at lower costs [12, 4]. Retailers fix some important variables, such as store product segmentation, category management, planograms and delivery patterns and replenishment lead times, at a tactical level and pass the decisions to the execution level as parameters [12]. How the different tactical planning issues affect the retail operations (stores, transportation and distribution) and responds to demand has been treated to a limited extent [12, 4]. Even though the basic structure of a coordinated planning framework in the grocery retail industry has been proposed [7], the interdependency of the planning decisions requires a good balance between individual planning processes and supply and demand management. The need for more integrative retail logistics and collaborative planning has been identified [7, 12].

This study addresses tactical planning processes in retailing. In particular, the purpose is to analyse the planning processes and their aim, and to what extent these are integrated to serve the need for alignment and demand responsiveness. Consequently, the research questions are how is tactical planning conducted at a retail company and how are the different plans connected and interact?

2. Literature on retail planning

The main objective of mid-term, aggregated supply chain (SC) planning is to build a plan that satisfies demand while maximizing profit [2] in a timely manner. Mid-term planning often covers multiple SC stages [11, 6] is based on aggregate demands for entire product families and covers a medium-term horizon. Creating such a collaborative plan could be challenging since different functions may achieve profitability in conflicting ways. Coordination between stages and functions becomes the core element in SC mid-term planning.

Retail operations and SC management in the retailing context have been largely studied [5]. Most studies focus on some aspect of planning, like delivery patterns [12], in-store operations [13], retail store replenishments or reducing waste in fresh food SCs [10]. An overall understanding or syntheses of retail planning are rarely presented, with an exception being the grocery retail planning framework by [7]. Mid-term planning comprises several planning phases conducted by and related to one or more functions. First, mid-term planning deals with *category and product-related aspects* that are grouped as product segmentation and allocation (covering issues related to procurement and logistics) and master category planning, related to sales. Second, mid-term planning covers plans for managing the product flow (inbound planning, production planning and distribution planning) and in-store planning, including capacity and personnel planning.

Agrawal and Smith (2009) [1] describe a more process-oriented SC planning framework at a (furniture) retailer covering the planning steps, their succession and interrelation. Based on combining the two SC planning overviews, the different planning activities are discussed below. Following the planning process design [8], we identified, based on theory, *design parameters* (planning horizon and aggregation level), *inputs*, *outputs*, *objectives* and *functions* involved in each planning phase.

In grocery retail, selection of vendors is more a strategic decision [7]. For products that are carried over multiple seasons, contracts may allow for modifications in order quantities within certain ranges, depending on the observed demand for the product. In addition, retailers can evaluate vendors based on past performance and can be involved in the vendors' production planning more actively or by sharing forecasts and placing purchase orders [1].

The planning of product logistics deals with coordination of flow of products from suppliers to warehousing and to retail stores. These decisions are made on different planning objects, product-specific and product segment-specific decisions. For inbound logistics, the following planning issues are done at different levels of aggregation: supplier-specific level (related to product ordering) and supplier-segment level (related to transportation issues). Distribution planning deals with decisions to fulfill customer service targets at minimum costs as a trade-off between inventory management policies for each store and delivery policies from the central warehouse. As in inbound planning, the decisions are done at different aggregation levels, some are store (concept) related and others focus on delivery regions.

3. Methodology

The aim of the study is to understand the tactical planning processes in grocery retailing. The methodology we chose is a single exploratory case study since this allowed us to gain the needed in-depth insight into the planning process and to enable us to study the planning process in its natural environment [3]. A single case was selected in the grocery sector because of the novel nature of the retail planning process and the wide product range and the mix of product types (fresh, frozen and dry food), which make it relevant from a planning perspective.

Data were collected in two steps. First, site visits and workshops focusing on describing processes and operations, and observations at warehouses and stores were the main means to understand the planning environment. Second, the data about the tactical planning process were collected in structured interviews following a case study protocol designed to cover the objective and content of the tactical planning process, the structure of the planning processes, planning interconnectedness and performance. [14]. The interviews took place at three levels: retail chain, procurement and suppliers and logistics and it involved key managers with responsibility for tactical planning. The field notes from the interviews were converted to a description of the tactical planning and structured according to the literature in section 2. We asked the key interviewees to review the case description to ensure its validity [14].

4. Results

4.1. Case description

The case is a Nordic grocery retailer offering a full-range grocery assortment. The organization is structured into three main functions: retail chain (stores), procurement and assortment, and logistics. Altogether, the retailer runs hundreds of stores divided in different store concepts ranging from discount stores and supermarkets to premium stores. Centralised planning tasks include the development of the different store concepts, their assortments, marketing, sales and promotions and various purchasing and supplier network decisions. Managing the logistics consists of the inbound logistics from suppliers to the warehouses, warehouse operations and outbound logistics to the stores.

4.2. The tactical planning process

Figure 2 illustrates the tactical planning process, while Table 1 includes a more detailed description of each activity. The tactical planning process takes place at all three functions (Figure 2), but contrary to what is illustrated in the framework presented by [7], the process begins at the retail chain. The tactical planning process can be described as follows: (1) The retail chain decides the main profile of the chain concept and the product categories (category, profile, depth, price, etc.) and promotions for each concept. The decisions are made at an aggregated level covering a time horizon of 12 months, with two main objectives: revenue and profit per chain concept. (2) This plan is afterwards disaggregated into specific products, volumes and time periods for the promotions. (3) Additionally, the specifications of each profile act as an input to the procurement and assortment function, which disaggregates the master category plan into specific products and suppliers while (4) negotiating and making the final contract with the suppliers. The suppliers' contracts regulate the terms and conditions for the purchase and deliveries (price and discounts, volume, frequency, promotions, packaging size) for a 12-month period, while the planograms for each store or store concept are updated every 4 months. Planograms define where specific products are placed on shelves and the stock level. (5) Based on the volumes specified in the contracts and the expected sales in each area (can be derived from the sizes of the shelf in the planograms), the inventory structure is decided upon. This may be adjusted during the year. Hereafter, (6) to ease inventory management decisions, all products are divided into different logistical product groups, which should share the same service level before (7) the final inventory policy and delivery plan is finalized. By grouping the suppliers into smaller regions, the inventory and delivery plan specifies when and how much to collect from each supplier. Lastly, the plan for outbound deliveries from warehouse to stores is made on two hierarchical levels, also with a varying time horizon. Based on the profile of each concept or the store revenue and the inventory structure, (8) guidelines are provided for the number of weekly deliveries for three high-level product groups: a) frozen/dry/fresh food, b) fruits and vegetables and c) products from the central warehouse. Large stores get more frequent deliveries than smaller stores. Finally, (9) the individual routes from the warehouse to the stores are calculated by balancing the delivery plan with the utilization of each truck.

Figure 1 shows that planning is top–down oriented by starting at an aggregated level and letting the aggregated decisions be the premises for lower level planning. We observed two layers in the tactical planning: one that focuses on a 12 months horizon and is aggregated (store concept and product category) and the second that focuses on product family and individual products and has a 4-month time horizon.

The planning is functional, and the output from one function acts as the input and sets the premises for the next function. Limited feedback loops and interaction between the planning steps are apparent. At the tactical level, there is no joint planning team that joins and coordinates the main planning areas to integrate and align between the functional plans. However, the company does apply different types of meetings to discuss cross-functional issues between the plans.

For each tactical plan there are objectives that serve the aim of the function. Revenue and profit are the objectives of the retail chain, and logistics is measured according to the cost and service level. At this level there do not appear to be any cross-functional objectives that align the SC.

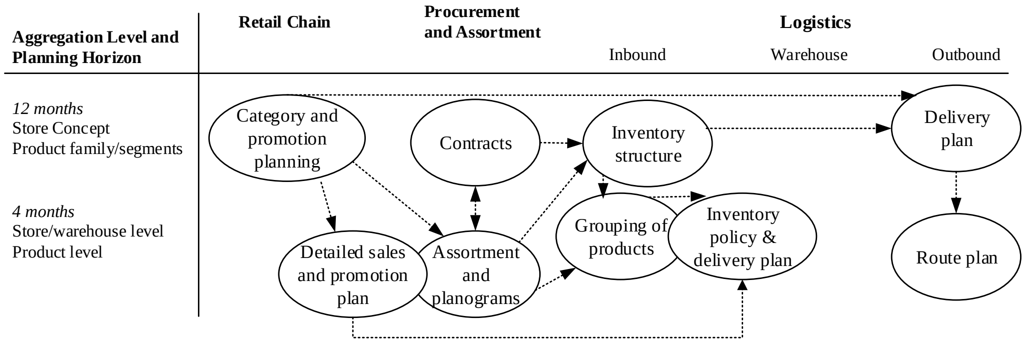

Figure 1. The sequence of tactical planning phases in the case company.

Logistics planning is done under the constraints set in former planning steps, and the aim for logistics is to focus on cost and delivery service to stores given the assortment decided on. Similarly, the stores operate on decisions made by the retail chain and procurement and assortment.

5. Discussion

5.1. Content and sequence in a tactical planning process

Planning in the case company has several of the characteristics described in the literature. We observed the functional structure of the planning described by [7], but we also found the planning was process oriented, including different steps and sequences as [1] describe. The planning in the case company started in the retail chain, which decided the master plan for the chain and assortment concept, followed by the assortment and sourcing decisions before logistics decided how and when to move products. Additionally decisions taken on a higher level is the input from lower planning levels, the planning follows a sequence and is repeated every 4 or 12 months.

The initial planning phases seem to be driven by demand management objectives [2], while the later phases are driven by supply management. The start of the planning process is the master category, store profile and sales and promotion decisions, which set premises for the rest of the planning. The retailer obeys the practice presented by [12] as it fixes some variables such as store product segmentation, category management, space management and planograms and delivery patterns and replenishment lead times, on a tactical level and passes the decisions down to the execution level as parameters. The next planning step also focuses on demand management decisions as procurement and assortment decides on the products and suppliers. When logistics is brought into the planning process, then supply management aspects are brought into the planning such as inbound and outbound logistics and distribution.

The planning process makes the planning inert since the outcome of the higher level planning is fixed for a long time horizon (12 months) and it is top–down oriented.

Table 1. Description of planning process

Activity	Aggr. / Horizon	Input	Output	Objectives	Functions
(1) Category and promotion plan	Store concept Product family	Limited restrictions	Profile of each concept, including price range and promotions	Profit Revenue	Retail Chain
(2) Detailed sales and promotion plan	4 months Product level Concept	Input from master category planning Demand forecast or similar promotions	Specify products - Volume, time and period - Price/promotion per product/concept - Input to inbound logistics call-offs	Revenue Profit Waste	Retail Chain
(3) Assortment and planograms	4 months Product level Store/concept level	Profile of the concept	- Specify products - Shelf allocation (planograms)		Procurement Spacing
(4) Contracts	12 months Product/family	Assortment	Supplier contract (yearly volumes, delivery frequency, discounts)		Procurement
(5) Inventory structure	12 months/Trigged by season/as needed Product level	Warehouse capacity, Store demand, Seasons, Locations of suppliers	Storage/location plan (where to locate each product)	Warehouse capacity	Logistics
(6) Grouping of products	4–12 months Product level	Planograms	Allocation of individual products into A,B,C,D,E categories for planning decisions–service level		Logistics, Procurement
(7) Inventory policy and delivery plan	4–12 months Product/Category level	Product shelf life Balancing transportation cost and inventory cost Demand uncertainty Discounts	Quantity Time/frequency Safety stock Grouping suppliers into regions and delivery frequency	Service level Warehouse waste Tied-up capital	Logistics
(8) Delivery plan	12 months High product family level	Profile of the concept/Store revenue Inventory structure	Delivery structure for stores - Delivery frequency - Delivery time	Service level Waste & cost Dry, Inv. turnover max 12 days	Logistics
(9) Route plan	4 – 12 months Store level	Delivery plan Size of trucks	Routes for deliveries to stores		Logistics

This makes the planning more predictive and less sensitive to disturbance and market changes and makes it easier to focus on resource utilization and efficiency. However this makes the planning less dynamic and adjustable to the actual demand situation. Long-term assortment planning and promotion planning (12 months) actually stabilize the planning, and other plans are adjusted.

5.2. Interplay between organizational functions

Constraints are decided by the objectives of the retail chain and procurement and assortment function, and the main role of logistics is to make a plan that optimizes cost and service level. The 'what' decisions are managed by the retail chain and assortment and procurement, leaving the 'when' and 'how much' decisions of warehouse, transport capacity and delivery frequency to the inbound and outbound logistics planning. The store profile and assortment planning constrains the following planning phases to an extent that the other plans keep the role of implementing the plan.

The overall tactical planning process is fragmented as it consists of a set of sequential plans that are only loosely integrated. First, coordination is done when needed and there is no common arena for integrating all the functions that are involved in the process in order to have consensus in the planning. When planning is done in quite separated loops that serve different demands, they can easily end up in sub-optimising. Second, the planning objectives are different in the main planning functions; some obey commercial objectives, revenue and profit, and others cost and service level. The planning is driven by several goals, but it remains unclear how the planning quality is defined and measured.

Some improvement proposals emerged. First, the different plans can be better coordinated and integrated in general. Second, there need to be efficient feedback loops from implementing the plan to tactical planning. This is essential for keeping the plan responsive to demand and achieving alignment. The company needs to have a practice to update the plan between planning rounds if needed. Third, the whole process, particularly the operational part, could benefit from adopting more formal practices. Instead of the reactive way of operating, with ad hoc meetings and fire fighting, the company could operate in a more proactive manner. Furthermore, we suggest that differentiated planning [9] can be realised to some extent.

6. Concluding Remarks

The operating environment of retail business increases competitive pressure because of multichannel operations, global sourcing and increasing number of product variants. To survive in this competitive environment, retailers need to ensure product availability at stores and at the same time operate efficiently. Our study examines how a retail company has implemented these challenges in its planning solution.

The case company uses a solution for defining retail store assortments for a long period of time and ensuring the supply of products by supplier agreements. This practice stabilises the planning and sets targets for the operations. The downside of the practice is the low level of demand responsiveness. In this paper we suggest that the company, if better demand responsiveness is desired, could realise formal feedback loops from operations to assortment planning. This would allow adjusting the assortment. This could be applied when planning the next 4-month assortment but also between the planning rounds. The company could also benefit from more formal planning practices and integration mechanisms in realising integrated planning.

This study reports initial results from an on-going research project concerning one retail company. The next steps are to collect more data, particularly on outbound logistics and store planning in order to look deeper into demand responsiveness.

7. Acknowledgements

The authors gratefully acknowledge the BIA program, the Norwegian Research Council for financial support of the project and the participating case companies.

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Paper #7

Enhancing tactical planning in grocery retailing with S&OP

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Purpose: This paper explores tactical planning in grocery retailing, and propose how the sales and operations planning (S&OP) concept from manufacturing industries can be applied in grocery retailing. The study proposes directions for designing tactical planning process in grocery retailing.

Design/methodology/approach: The work is an explorative case study with four cases in the grocery retailing in Finland, Norway and the UK.

Findings: The study contributes to the S&OP literature by providing contextualized empirical insight into tactical planning in grocery retailing. Grocery retailers serve price-sensitive consumers, and demand is affected by seasons and demand stimulating activities. Planning resources are directed to managing the market events. Less attention is directed towards aligning demand and supply, or to providing a single plan to guide company operations.

Research limitations/implications: The study is based on four case studies in grocery retailers. Comparisons between retail industries could be valuable to understand the contextual planning characteristics of retailing.

Practical implications: The study provides guidelines for practitioners how S&OP can be adapted in retailing and presents propositions for how tactical planning could be improved.

Originality/value: The study complements earlier research on retail tactical planning by taking the planning process and integration aspects. The study suggests that retailers need such a leadership that enhances a planning-oriented company culture. Retailers would benefit from a formal and company-wide S&OP process to unify different market-oriented plans to a single set of numbers, and balance demand and supply, without sacrificing the emphasis on demand planning.

Keywords: retail planning, grocery, sales and operations planning, tactical planning process, planning integration.

Submitted for 3rd review: International Journal of Physical Distribution and Logistics Management

Role of the PhD candidate and declaration of authorship:

Heidi Carin Dreyer conceptualized the paper. Kasper Kiil contributed to data collection from all four cases together with either Heidi (case 1, 3, and 4) or Riikka Kaipia (case 2). The paper was jointly written by all authors. Specifically, Kasper composed the interview guide, conducted the initial within-analyses as well as contributed to the joint development of the propositions. All authors contributed significantly to refine the whole paper during the review process.

Enhancing tactical planning in grocery retailing with S&OP

1. Introdution

Grocery retailers serve a competitive and demanding market with well-informed consumers expecting excellent product availability, rich assortment, fresh products, and low prices (Hübner *et al.*, 2013; Kuhn and Sternbeck, 2013). Effective and efficient demand and supply planning is essential for coordinating thousands of individual and time restricted decisions in the supply chain (Hübner *et al.*, 2013). However, grocery retailing is characterized by high demand uncertainty (Taylor and Fearne, 2009; van Donselaar *et al*., 2010; Ettouzani *et al*., 2012; Alftan *et al.*, 2015), large and changing assortment (Hübner *et al*., 2013; Ketzenberg *et al.*, 2015), and supply uncertainty, which can reduce the product availability (Hubner *et al.*, 2013; Alftan *et al.*, 2015). Coping with these features have lead the retailers to require short lead times from suppliers to be able to respond to the changing demand requirements, but they still need solve the problem of poor demand forecasting, seasonality in demand and supply, and short product life cycles (Småros, 2007; Fernie and Grant, 2008; Van Donselaar *et al.*, 2010). Proper tactical planning may provide stability in this regard, as it sets the premise for further operational decisions.

In retailing, tactical planning determines ground rules of regular operations for the coming 6-12 months, considers seasonal demand patterns as well as yearly business plans when negotiating with suppliers (Hübner *et al.*, 2013). Tactical planning in retail has been implicitly present in concepts such as efficient consumer response (ECR), quick response (QR), vendor managed inventory (VMI) and collaborative planning, forecasting and replenishment (CPFR) (Aastrup *et al.*, 2008; Holmström *et al.*, 2002), with a focus on collaborative demand and supply management. Only recently, tactical planning in retail has been explicitly identified and analysed (Hübner *et al.* 2013; Kuhn and Sternbeck, 2013). However, these works are limited to the types of decisions made and only partly their interrelation without examining the process and integration. This might be highly relevant, as the demand-driven category management and the supply-oriented operations management aspects are still planned in a quite separated manner internally in the retail organization (Kuhn and Sternbeck, 2013).

In the manufacturing industries, tactical planning concepts has been well established, clearly separated from operational and strategic planning (Fleischmann *et al.*, 2008). Particularly, sales and operations planning (S&OP) is an established a well formulated planning process aiming to maximize the profitability of a company by aligning and integrating customer demand with supply (Tuomikangas and Kaipia, 2014; Wagner *et al.*, 2014). In S&OP, integration is enhanced through a set of mechanisms aligning business strategy and operational planning, as well as aligning the involved business functions and supply chain partners (Affonso *et al.*, 2008; Wallace, 2011). A growing body of literature has studied S&OP in manufacturing context, however, it has rarely been discussed in retailing (Harwell, 2006; Olivia and Watson, 2011; Kuhn and Sternbeck, 2013) even though a need for studies in different industries has been identified (Thomé *et al.*, 2014). These observations indicate a need for exploring the mid-term planning processes in retailing.

The purpose of this paper is to explore tactical planning in grocery retailing, and propose how the S&OP concept from manufacturing industries can be applied in grocery retailing. We fulfill this purpose by examining two research questions:

1. How is tactical planning and planning integration in grocery retailing?
2. How can S&OP be adapted to grocery retailing to enhance the tactical planning process?

The study contributes to the S&OP literature by providing contextualized empirical insight into tactical planning at grocery retailers and suggesting directions for adjustment to the well-established S&OP process. In relation to the grocery retailing literature, the study proposes a process and integration elements that can improve the formalization of the tactical planning. Managerial-wise, the study gives a proposal and recommendation for S&OP in grocery retailing.

The remainder of this paper is organised as follows: First, based on literature we outline the contextual dimensions of grocery retailing and develop a theoretical framework for analysing the tactical retail planning process and the integration. Second, the use of case study research is described. Third, we analyse the tactical planning processes in four cases from grocery retailing, followed by a cross case analysis. Lastly, we discuss our findings in relation to previous literature and propose recommendations for retailers and for future research.

2. Theoretical framework

The theoretical framework is structured around the elements of supply chain planning, in particular the processes and level of integration applied to manage operations and relationships (Jonsson and Holmström, 2016). The section starts with a review of S&OP. Afterwards, to address the specific context, literature from retail tactical planning is discussed from the viewpoint of process and integration.

2.1. S&OP as a process

According to its most basic definition, a process is a sequence and interdependency of *activities* across time and space (*setup*), with a beginning and an end, and clearly identified *inputs* and *outputs*, designed to achieve a goal (Davenport, 1993; Oliva and Watson, 2011). S&OP is a continuous and interactive process, and is typically organised around five main *activities* (Wagner *et al.*, 2014). It starts with *updating data* regarding past performance (such as the past month sales, production quantities) and *disseminating data* relevant for the development of the new forecasts. The next two activities in order to analyse the actual vs. planned performance are the *demand* and *supply planning* and to *develop new unconstrained demand and supply plans*. During the fourth activity, *pre-meeting*, representatives from different functions on both demand and supply sides meet to discuss and adjust demand and supply plans within the frame of policies, strategies and business plans. In the final activity, pre-meeting decisions are either approved or further discussed and decided in an S&OP *executive meeting*. This basic S&OP process has developed to include other supply chain stages and partners (Affonso *et al.*, 2008; Wang *et al.*, 2012). In the cases of highly variable supply, as in the food and drink industry, Yurt *et al*. (2010) propose that the S&OP process should be adapted with an initial supply planning which will be passed on to the demand planning (Figure 1). Similarly, Ivert *et al*. (2015) find that industrial food producers adjust their S&OP processes by adopting specific activities related to supply planning (forecasting of raw material quantity and quality, or what if scenarios in supply planning).

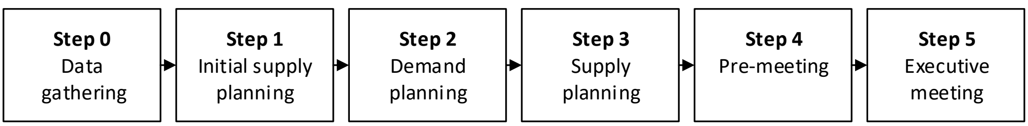

Figure 1: S&OP process activities for a case of highly variable supply (Yurt et al., 2010)

The *setup parameters* of the planning process refer to the planning horizon, planning frequency and planning object (Jonsson and Mattsson, 2009). In a food producer context, the S&OP *planning horizon* is between 1 and 2 years and depends, besides other factors, on the supply seasonality, contracts with sub-contractors and customers (Ivert *et al.,* 2015). In addition, some food producers differentiate the planning horizon for different decisions (Ivert *et al.*, 2015). The most common *planning frequency* is monthly (Lapide, 2005; Grimson and Pyke, 2007; Ivert *et al.*, 2015) though at food producers, more frequent planning is common (Yurt *et al.*, 2010; Ivert *et al.*, 2015) because of the promotion-intensive nature of the industry. Generally, the *planning object* in S&OP is the product family (Jonsson and Mattsson, 2009), but in a food producer context a more detailed planning level, the stock keeping unit (SKU), may be warranted because of environments with high variety of products and high number of product launches (Ivert *et al.*, 2015).

The *inputs* of the S&OP process consist of plans, forecasts and information on customers, suppliers, resources, capacity and inventories, and the S&OP goals (Thomé *et al.*, 2014). The emphasis in the literature is on demand, sales and production plans, but in advanced forms S&OP deals with procurement, supply, distribution and financing. Ivert *et al.* (2015) find that material supply uncertainty and its forecasts are important input in the food producers' context. A main *outcome* of the S&OP process is partial or comprehensive integration, both horizontal alignment of different functional plans and vertical alignment of the strategic and operational plans (Thomé *et al.*, 2012; Wagner *et al.*, 2014). Some companies focus on integration of sales and demand forecasts, others on procurement and supply planning etc. Table 1 summarises the S&OP process variables identified from the literature.

Table 1: S&OP process variables.

Process variables	**Indicators**
Activities	Data gathering, demand planning, supply planning, planning consensus and planning approval.
Setup	Planning horizon, planning frequency and planning object.
Input	Plans, forecasts, constraints and information on customers, suppliers, resources, capacity and inventories.
Outcome	Level of incorporation of sales information into supply planning and vice versa. Direction of planning process: one-way/sequential or two-way/concurrent. Forecast and plans developed in top-down (driven by business and financial goals) or bottom-up approach (driven by operational considerations and sales forecasts).

2.2. S&OP mechanisms to enhance plan integration

Integration in general refers to special building blocks that cause firms (or functions) to collaborate in the long term (Morash and Clinton, 1998; Stock *et al.*, 1998; Chen *et al.*, 2007; Vieira *et al.*, 2009). In the S&OP literature, integration has been operationalized as types and degree of collaboration and participation between different functions (Tuomikangas and Kaipia, 2014) degree of resource sharing, collaborative process operation and improvement (Nakano, 2009). This study is based on the mechanisms proposed by Grimson and Pyke (2007) because their research explicitly explores and identifies a (strong) relationship between each of the mechanisms and plan integration. The mechanisms of process integration are elaborated in Table 2.

Table 2: S&OP mechanisms enhancing plan integration.

Mechanisms	Indicators
Meetings and Collaboration	Level of involvement in cross-functional planning meetings. Span of collaboration in development and use of input data and separate plans Level of formalisation of the meetings, regularity of meetings, communication between meeting rounds Alignment of goals
Organisation	Formalisation of S&OP function and team Level of empowerment and executive participation
Performance Measurements	Span of measurements across functions Cross-functional accountability for different targets Measurements of S&OP effectiveness
Information Technology	Level of ownership of information and its update Level of sharing and consolidation of information Level of advancement in technology for decision making

The first three mechanisms appear to be more important for plan integration, while the IT mechanism seems to gain importance when aiming to achieve higher levels of S&OP maturity and plan integration (Grimson and Pyke, 2007). I.e. when the external collaboration comes into play and trading partners need to share data on planned product promotions (or new product introductions) and feedback (Goh and Eldridge, 2015).

2.3. Characteristics of grocery retailing which affect planning

Previous research has identified aspects of the planning environment that affect the design of the planning processes (Jonsson and Mattsson, 2003; Olhager and Selldin, 2007; Kaipia and Holmström, 2007; Fredriksson *et al.*, 2014). Ivert *et al.* (2015) have identified that for the S&OP planning level, the process and the setup are affected by the characteristics of the planning environment related to product, demand, and supply. In the sequel, each of these characteristics is elaborated for the retail environment.

2.3.1 Product-related characteristics

There is a large number of grocery products (Agrawal and Smith, 2009), up to 50,000 items (Hübner, 2011), is continuously growing (Kaipia and Tanskanen, 2003) and there are inter-relationships (e.g. cannibalization) among the products (Agrawal and Smith, 2009). In addition, product life cycles are shortening while the change-rate is accelerating (Kaipia and Tanskanen, 2003). However, products from the permanent assortment have a stable life cycle compared to other industries (Hübner, 2011). Lastly, even though the products are highly standardized, they are considered heterogeneous (Hübner, 2011).

2.3.2 Demand-related characteristics

Retail is organized in multiple marketing channels, such as supermarkets, discounters, hypermarkets, food service, and on-line retailing to target different customer segments, which increases the complexity (Agrawal and Smith, 2009; Dani, 2015). Demand fluctuations and uncertainty are driven by seasonality, promotional activities, and interrelation of the products (Hübner, 2011). Products from the permanent assortment have stable prices over mid-term period compared to other industries, while the promotional articles have dynamically varying prices (Hübner, 2011). High availability requirements are propelled by a fierce competition and the consequent risk of losing sales, and compared to manufacturing, consumers have to be served immediately. Additionally, grocery retailers need to proactively manage supply and demand requirements (for example by varying product offers and prices) until the consumer purchase (Hübner, 2011). Hereof, forecasting and sales planning gain higher importance than other industries (Hübner, 2011).

2.3.3 Supply-related characteristics

Retailers source products from many suppliers (Hübner, 2011) as well as use multiple brands and suppliers for the same product type (Agrawal and Smith, 2009). The replenishment cycle needs to be short and reliable because of the short shelf life of the products and the high service level requirements (Hübner, 2011). This is in contrast to the long lead times and the seasonality of the raw materials for the grocery products, as well as their sensitivity to weather and other environmental conditions. Additionally, different grocery products have dedicated distribution requirements, e.g. cooled, ambient, fresh (Hübner, 2011; Agrawal and Smith, 2009).

2.4 Tactical planning in retailing

The main grocery retail management initiatives, such as efficient consumer response (ECR), have attempted to integrate retailers and manufacturers/suppliers to fulfil the consumer needs better, faster and at less cost (Aastrup *et al.*, 2008). They incorporate logistic driven strategies and processes constituting efficient replenishment (ER) such as cross docking and continuous replenishment. Also demand and marketing driven collaborative processes have been developed for category management (CM), such as efficient store assortment (ESA), efficient promotion (EP) and efficient product introduction (EPI) (Corsten, 2000). To bridge the gap between demand and supply side planning, a collaborative planning, forecasting and replenishment concept (CPFR) emerged (Holmström *et al.*, 2002). However, the process is mainly demand driven and one-directional, proceeding from sales forecast to logistics forecast (Holmström *et al.*, 2002). Further developments of this process, such as collaborative buyer-managed forecasting (CBMF) (Alftan *et al.*, 2015) focus more on how to improve the forecasting in order to better handle exceptional demand situations when replenishing.

An interesting contribution to retail planning research is provided by Hübner *et al.* (2013), who propose a synthesis of retail planning, and designed a demand and supply chain planning framework, which incorporates the most relevant retail chain planning problems. At the tactical level, the planning is divided on two levels of aggregation for the decisions. The upper level deals with *master category planning* that covers sales aspects, and *product segmentation and allocation* that covers issues related to procurement, warehousing and distribution. On the lower level, it considers *plans for managing the product flow* (inbound planning, production planning and distribution planning) and instore planning, including capacity and personnel planning. In addition, these planning decisions are related to the different functions of the retail supply chain that are assumed to be taking part in developing the plans, and are distributed across different hierarchical levels of planning. Even though the framework outlines and structures the main demand and supply chain planning issues, it does not reflect a planning process or interrelation between the various decisions towards a common goal. In addition, there is still clear division between operation related and sales related planning activities.

Retail planning has been studied in a large group of articles, but this literature typically focuses on planning aspects of specific parts of supply chain, such as delivery patterns (Kuhn and Sternbeck, 2013), instore operations (Kotzab and Teller, 2005; van Donselaar *et al.*, 2010; Reiner *et al.*, 2013), retail store replenishments (van Donselaar *et al.*, 2010; Alftan *et al.*, 2015) or waste reduction in fresh food supply chains (Kaipia *et al.*, 2013). Kuhn and Sternbeck (2013) identify five tactical planning issues related to *operations* at retail and explore their implications for stores, transportation and distribution centers.

To summarize, there has been successful attempts to increase collaborative planning in retailing, and to enhance forecasting and information sharing in planning. Even though for example ECR has brought suppliers and retailers into the same process, there is still missing a more balanced view on the tactical supply and demand planning for grocery retailers.

3. Research Design

To serve the purpose of this paper, exploring tactical planning in grocery retailing, and propose how the S&OP concept from manufacturing industries can be applied in grocery retailing, an exploratory case study approach was designed. Case study research is particularly suited when exploring new and complex real-life events (Yin, 2009), where the context and experience are critical for understanding the phenomenon of interest (Barratt *et al.*, 2011), and when research builds on existing theoretical frameworks (Voss *et al.*, 2002).

The unit of analysis is the tactical level of planning in grocery retailing with a focus on the process and the planning integration. We aim to investigate the theory and the retail context in turns by iterating between the theory and the empirical data which is an approach that can be characterized as theory elaboration (Ketokivi and Choi, 2014; Narasimhan, 2014). Theory elaboration focuses on contextualizing a logic from a general theory, or in other words: reconciliation of the general (in our situation: S&OP) with the particular (the context of grocery retailing derived from case studies) (Ketokivi and Choi, 2014).

3.1. Case companies

The research involved four cases in the grocery retail sector in Finland, Norway and the UK. The purpose of case studies are generally not intended to generalize findings, but merely to empirically shed light and to further elaborate on a theoretical concept (Yin, 2009). Consequently, we used three main selection criteria. (1) We selected cases based on our preliminary familiarities of several grocery retailers, which could include planning practices and capabilities at different maturity levels to broaden the empirical foundation for analysis and subsequent propositions. Using multiple cases also reduce the risk of misjudging the representativeness of single events (Voss *et al.*, 2002). (2) Grocery retailing is often characterized by a complex logistical network and broad product range, thus we wanted to ensure that the selected retailers have a large range grocery assortment and a large responsibility for wholesaling and logistics operations. (3) The cases were located in geographical areas with comparable characteristics such as the industry structure and the retailing business model which made the cases suitable for a cross-case analysis. The cases are further described in Table 3.

Table 3: Case features

Cases	Case 1: full range retailer	Case 2: full range wholesaler	Case 3: premium retailer	Case 4: discount retailer
Scope of company	Full range grocery retailer	Grocery wholesaler serving independent retail chains and cash-and-carries	Grocery retailer, premium stores and products	Grocery retailer serving discount stores.
Product types	Dry, frozen, chilled, bread and fruit and vegetables.	All types of grocery products, except frozen products.	Specialized in premium products, mostly fresh food and beverages.	Dry, frozen, chilled, bread and fruit and vegetables.
No of products	10,000 (8,500 in stock),	25,000–30,000, 16,000 in stock	13,000–14,000.	9,000–11,000 (5,000 in stock).
Number of customer retail chains and stores	6 appr. 1,200 stores.	4 app. 6,000 stores.	1 28 stores	1 appr. 600 stores.
No of employees	22,500	570	3,000	20,000
Supplier base	A large group of different suppliers.	A large group of different suppliers, due to large number of SKUs for the needs of variable customer chains.	A medium base of suppliers. Local suppliers favored, which typically are small suppliers with seasonal products.	Medium number of suppliers.

3.2. Data collection

Interviews with key informants and information from workshops (Table 4) have been the main data sources. Additional information was used, such as process and activity descriptions and documentations, time and calendar data, organisation charts, presentations, reports and memos.

For each case, workshops were organized before the interviews to become acquainted with the company and its operating principles, and to draw the broad picture of the planning. A case study protocol (Yin, 2009) was developed and used to support the theory-elaboration nature of the research (Barratt *et al.*, 2011; Ketokivi and Choi, 2014). An interview guide (Appendix 2) was designed to explore tactical planning in grocery retail based on S&OP process variables and integration mechanisms (see Table 1, Table 2). The framework by Hübner *et al.*, (2013) were used internally to gain an initial understanding of the grocery retail context and the tactical planning before conducting the interviews.

Two researchers were present during each interview; interviews were recorded and notes were taken. Directly after the visit, the interview was documented in field notes and summarised by the researchers; subsequently, it was sent to the company for approval and verification (Yin, 2009).

Table 4: Depth of involvement with the companies

Cases	**Case 1: full range retailer**	**Case 2: full range wholesaler**	**Case 3: premium retailer**	**Case 4: discount retailer**
Period	Jan. 2015–2016	June 2016	January 2016 and July 2016.	August 2016
Data sources	6 interviews (1,5-2 hours). Memos from meetings. 4 workshops (2-3 hours). Process mapping. Statistics and reports from business information systems. Annual reports.	3 interviews (1-2 hours). 3 workshop (2-3 hours). Planning process descriptions. Company presentation (slide set) Annual report 2015. Company web pages.	1 workshop (3 hours). 2 interviews (1,5 hour). Presentations. Company web pages.	1 interview (2,5 hours). 1 workshop (3 hours). Annual report. Web pages.
The role of the interviewees	Chain manager. Procurement manager. Logistics development director. Senior project manager. Logistics planner.	Planning manager. Sourcing manager. Supply chain analyst.	Supply chain manager. Supply chain analyst.	Distribution manager.

3.3. Case analysis

As suggested in the case study literature (Yin, 2009) the first analysis was a within-case analysis which was followed by a cross-case analysis (Barratt *et al.*, 2011). To structure the data analysis and to permit investigation of the theory and the context simultaneously, the frameworks in Table 1 and 2 were used to identify and classify the collected data (Eisenhardt, 1989; Miles and Hubermann, 1994). All the information from the cases, the field notes from workshops and interviews, and the additional documents and materials collected, were structured according to the theoretical frameworks and converted into process maps which included the activities, setup, and main inputs for the planning process (i.e. the constructs from Table 1). Also, the use of integration mechanisms (Table 2) was identified from the collected data and structured around the process map.

The analyses provided insights about the retail context and the existence of S&OP process elements and integration mechanisms in retail planning. To increase understanding on the retailing context an analysis on the contextual factors of each case and their effect on tactical planning was conducted. First the contextual factors from the demand, supply, and products characteristics were identified from the interview memos and other documentation. These were used to highlight and argue why S&OP in grocery retailing might (need to) be different. By reflecting on the case findings and the S&OP literature from manufacturing we extracted 6 proposition for enhancing the tactical planning in grocery retailing.

3.4. Research quality

Except case 4, all cases involved multiple respondents (and acted as multiple sources of evidences) as well as an approval of the field notes from the respondents after the interviews. This contributed to the construct validity of the phenomena under investigation as well as the possibility to clarify any doubts of the collected data (Yin, 2009). Internal validity was secured by defining the retail context, the concepts and their indicators and by using them in the interview protocol. External validity is achieved by having 4 cases reflecting different tactical planning practices.

The field notes were afterwards distributed to all authors acted as a case study database together with the interview guide and background material. This contributed to ensure all researchers had the same understanding of the basic concepts, terminology, cases, and issues relevant to the study. This database of literature and fields notes together with the case study protocol increases the reliability of the study and facilitates a potential replication of the study (Yin, 2009).

4. Within case analysis

The current tactical planning processes and the mechanisms for plan integration at the four cases are analyzed from the perspective of S&OP process and integration frameworks (Table 1 and 2) considering also the unique retail context.

4.1 Case 1: full range retailer

4.1.1 Planning process

Tactical planning is conducted in two generic time frequencies (1) yearly category, supply and capacity planning, and (2) periodical planning of market events (promotions, seasons and new product introductions) as shown in Figure 2.

Due to having six store chains, hundreds of stores and a broad and heterogeneous assortment sourced by a broad supplier base, the category planning is done aggregately and for each chain separately. The frequency is much lesser then the planning of the market events. This is needed in order to stabilize demand and supply by specifying with suppliers aggregated volumes needed and prices, and because of the long lead times of some raw materials in the grocery sector such as agricultural products. Input for deciding the volumes is the forecasting in the ERP system, while the main constraints are the access to raw materials, transportation utilization and warehouse capacity. Case 1 expresses the difficulty in managing when several events occur in the same period and there is a need for extra transport capacity in order to deliver the needed volume.

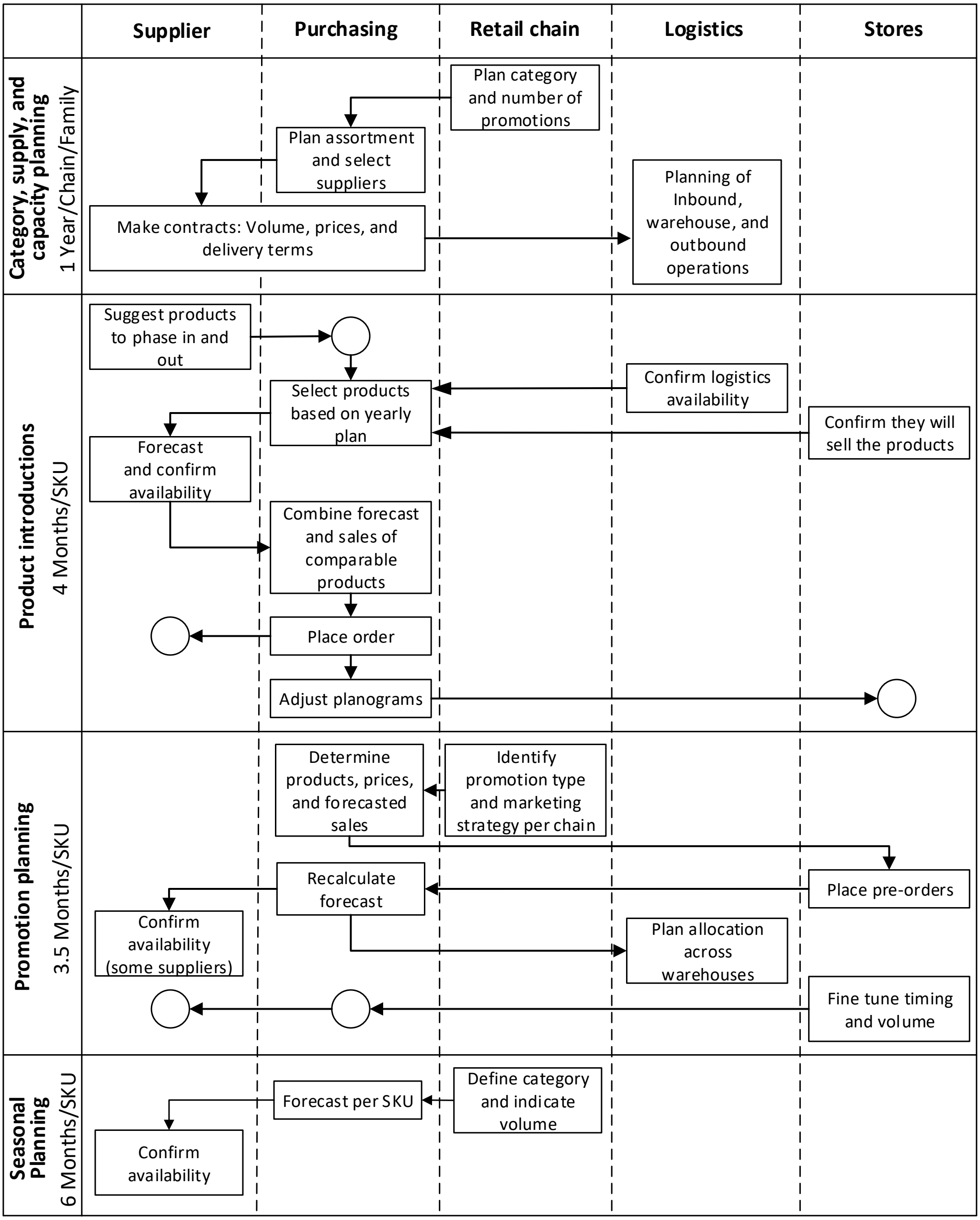

Figure 2: Tactical planning processes at Case 1

Launching new products is the only supplier driven event, which is typical for the grocery sector because the product owner is suppliers and it is a mechanism to regulate over- and undersupply of perishable raw materials and products (for example when quotas for fishing or milk are increased/reduced). The frequency is decided by country regulations and done three times per year in specific weeks. This planning process consists of series of iterations between the suppliers and purchasing aiming to better estimate volumes for the new products, ending with specific orders and change of planograms in the stores.

Promotions are the main mechanisms for stimulating demand and sales, and the company applies an aggressive promotion strategy, continuously running several promotions. Providing and improving forecasts as timely as possible is the main focus in order to achieve high service level. Input from the stores in a form of pre-orders and their fine-tuning closer to the event, is critical for improved forecast and for getting supplier commitments.

Planning of seasons is differentiated as: (1) planning of existing products whose volumes change because of seasonality influence (such as meat in barbeque season), and (2) planning of large seasons (such as Christmas). The first one is done in a process similar to promotion planning. The second one starts 6 months in advance to ensure availability of the products from the suppliers.

4.1.2 Mechanisms for integration

Tactical planning is conducted by three functions with limited cross-functional planning; demand management and event mechanisms drives the planning, followed by operations and supply planning. Case 1 does not optimize supply chain costs as a part of assortment planning, but logistics operations have to adjust to the assortment plan. Each planning team only calls for meetings with other teams if needed and when there is a conflict of interest. Forecasting is handled integrated in the enterprise resource planning (ERP) system, building on point of sales (POS) and product data from the data warehouse system. The forecast gives a joint input for all the functions and can be adjusted by individual stores. In addition, suppliers can have access to the forecasts. The KPIs reflect the individual functions and it seems that the KPIs are mainly used internally in each function rather than as input for improving the planning. Table 5 summarizes the mechanisms from Case 1.

Table 5: Integration mechanisms in Case 1.

Mechanism	Observations
Collaborative planning	Functional planning with limited cross functional collaboration. Some formalization of process. Some involvement with suppliers and customers.
Organisation	No fixed practical planning team and no executive support.
KPIs	Functional measures such as stock level, service level (to and from warehouse), delivery precision, order fill rate and waste level (in warehouse and in store).
IT	All information is collected and shared in a common ERP system.

4.2 Case 2: full range wholesaler

4.2.1 Planning process

Case 2 does internal logistics planning based on a forecast with a 6 months planning horizon since it is a wholesaler responsible for purchasing and (inbound and outbound) logistic activities (Figure 3). The rest of tactical planning is related to purchasing planning mainly initiated by its retail customers who are taking care of assortment decisions, events planning and store operations.

Case 2 copes with uncertainty in the planning by using POS data and annual supplier agreements from a broad set of suppliers. Additionally, there is a strong focus to secure reliable data by using IT system for capturing demand data, automation of replenishment decisions and information sharing.

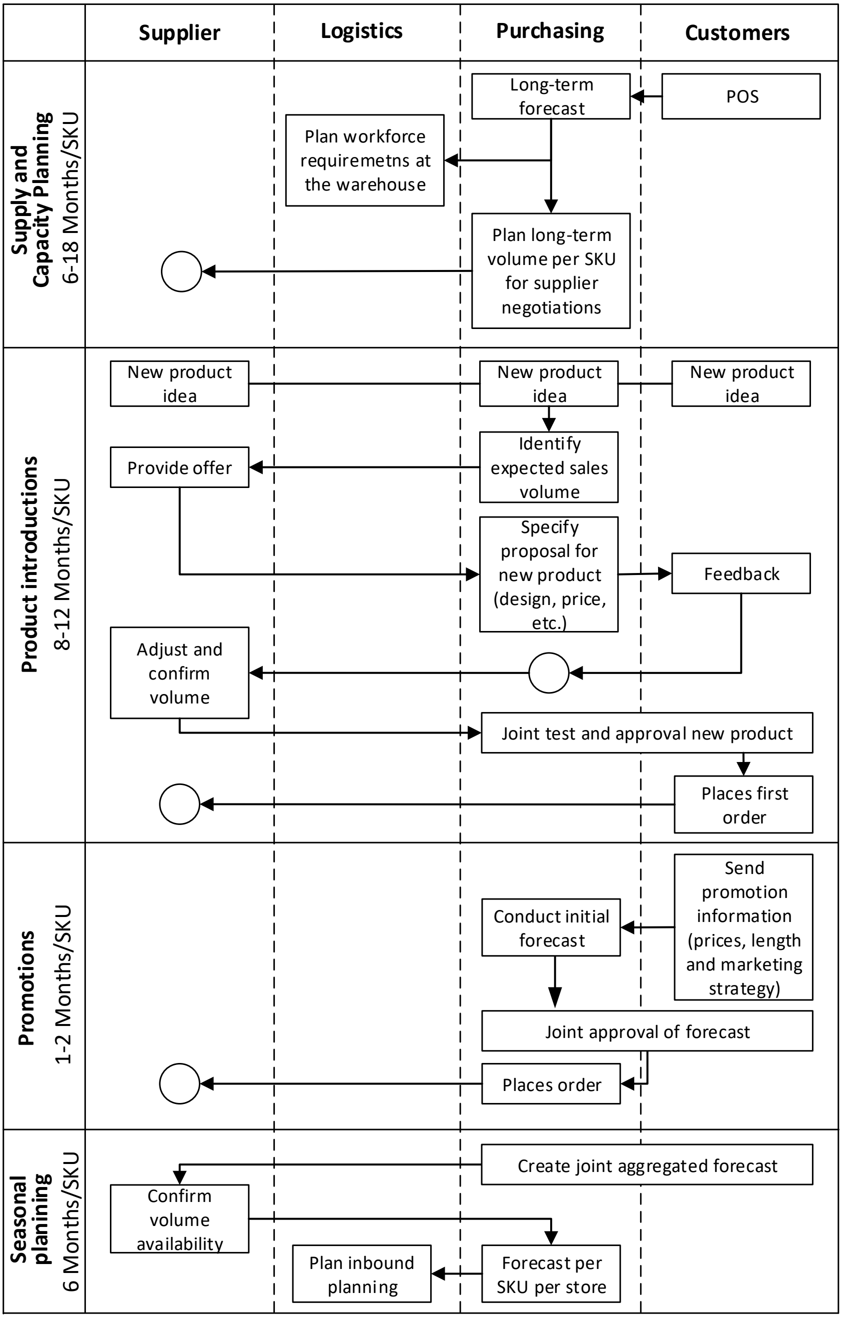

Figure 3: Tactical planning processes at Case 2

There are three types of planning performed with each of the four retail chains separately in order to ensure high product availability and short supply lead time.

For product introductions, depending on the product group, Case 2 meets with the retail chains 1-3 times per year to ensure that introductions occur in parallel. During this process, Case 2 investigates the feasibility of the production introduction initiative based on supply possibility, turnover, costs etc. which is a basis for further agreements with the supplier and the chains (price, number of stores, etc.). The main challenge from a perspective of the wholesaler is to get good prices since the volumes are decreasing (probably because of increasing number of products and large number of stores, thus increased variety).

The promotion planning process starts 4 weeks before the actual event since the customers prefers to deliver this information as late as possible in order to react to competitors' initiatives. The main focus is establishing final forecast on a daily SKU level, including the cannibalisation effect of the promotion. Within this process there is a lack of collaboration with logistics, mainly because of the short planning horizon which makes purchasing reacting and not actually planning.

Seasonal planning considers seasons of different length and volume variability, and seasons may overlap. Case 2 have identified different "rhythms" for seasonal planning were different products are linked to each rhythm which creates an overview and joint planning of the logistics needs for each "rhythms".

4.2.2 Mechanisms for integration

Planning is conducted through three individual processes, mainly handled by the purchasing function. Limited executive support and internal collaboration between the purchasing and logistics functions was observed. Because of the nature of the wholesaler being an intermediate between the suppliers and the customers, forecasts are shared with both suppliers and customers in order to get the right volumes on time. As part of the planning, they review performance measures (Table 6) which reflects functional performance rather than collaborative performance. Additionally, a common review of especially forecast accuracy is conducted together with the customers. All forecasting activities are handled in an advanced forecasting and replenishment system, which accesses customers' POS and uses information about the effects of previous promotions. This system is also being the main arena for integrations of plans.

Table 6: Integration mechanisms in Case 2.

Mechanism	Observations
Collaborative planning	Separate planning processes (promotions, product launching, seasonal, logistics), but with a rather formalized sequence and agenda. Involvement of suppliers and customers when needed
Organisation	All tactical planning is mainly handled by Purchasing. Limited executive support.
KPIs	Forecast accuracy of warehouse and of stores, fill rate and picking error at the warehouse
IT	Use of advanced forecasting and replenishment tool integrates internal functional planning.

4.3 Case 3: premium retailer

4.3.1 Planning process

The planning process in Case 3 conducts product introductions, assortment planning and seasonal planning in the same process and consists of three meetings which might be due to the limited complexity with only one retail chain and 28 stores and a main base of local suppliers (Figure 4). First, the event planning meeting (EPM) where the main purpose is to decide on a product family level the adjustments to assortment (phase in and out) and promotion types according the season of the year. The adjustments are made to reflect trends in sales and consumer satisfaction and typically covers the next 3-6 months. Second, the promotion planning meeting (PPM) where decisions from the EPM is disaggregated to SKU level based on availability checks at the suppliers. Case 3 is characterized by strong localness manifested by its desire to promote local products and events. Thus, suppliers are encouraged to provide an offer which can support the outcome of the EPM but also fit their availability of products. This helps to counteract the supply uncertainty found in grocery retailing. Additionally, even though the name of the meeting implies 'promotions', more detailed decisions related to assortment and seasonal changes also take place based on the input from suppliers. Third, integration planning meeting (IPM) is a collaborative meeting with suppliers where previous performance is reviewed and preparations for the following events to come.

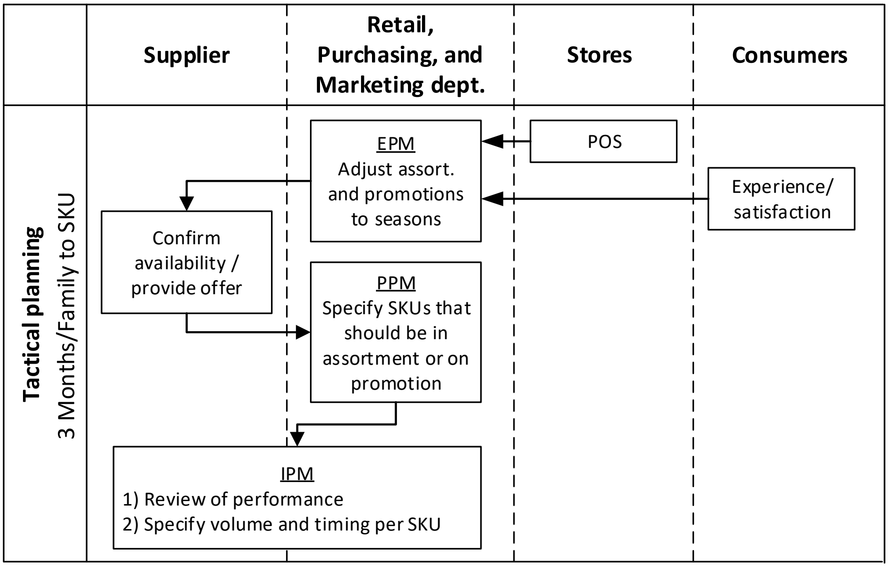

Figure 4: Tactical planning process at Case 3

The planning in Case 3 contains the basic elements of the S&OP process, even though the process starts with the executive meeting and does not function as a final sign-off.

4.3.2 Mechanisms for integration

The three meetings follows a fixed planning structure and with the aim to generate a single unified plan (for all stimulating demand activities) created by all main functions and with both downstream (POS and consumer experience) and upstream (availability and special offers) inputs. The tactical planning process is driven by the marketing department, but also the retail and purchasing department is heavily involved. The executive level is part of the consensus process and physical attendance is compulsory for the EPM. An explicit activity in the process is the review of past performance where key measures are used to evaluate performance specify for grocery retailing – particularly focus is placed on promotions effectiveness, forecast accuracy, shrinkage in product categories and inventory levels. Forecasting are handled in an advanced forecasting and replenishment system, which uses fine granulated sales information from the stores. Table 5 summarizes the mechanisms from Case 1.

Table 7: Integration mechanisms in Case 3.

Mechanism	Observations
Meetings and collaboration	Highly formalized set of meetings between all functions with fixed agenda and frequency. Involvement of suppliers and customers.
Organisation	Clear cross-functional team handling the tactical planning process with executive support.
KPIs	Use of rather wide KPIs such as promotion effectiveness and product shrinkage.
IT	Use of advanced forecasting and replenishment tool.

4.4 Case 4: discount retailer

4.4.1 Tactical planning process

The planning in Case 4 is conducted on two time horizons: yearly planning and mid-term planning (Figure 5). Decisions about category, assortment and purchasing is taken by the supply chain and the category/purchasing team, and together with suppliers they establish a yearly agreement for the assortment on promotions on a volume level acting as input to the aggregated inbound plan. This enables suppliers to plan for the long production times found in grocery retailing. The yearly agreement is used to generate planograms and aggregated inbound transportations plans.

The mid-term planning consist of product introductions and a combined process for promotions and seasonal planning. Product introductions are driven by the suppliers, and the main task for the grocery retailer is to select which of the proposed products they want to include in the assortment and to confirm the forecast provided by the supplier. Previously, suppliers struggled to deliver the required quantities for product introductions. Consequently, the process was formalized to be more supplier-driven to provide them with a better possibility to cope with supply uncertainty.

The promotion and seasonal planning is made once a month for the next 2–3 months; exceptions are long seasons, such as Christmas, where the assortment, initial volume estimation and supplier involvement begin long time in advance. Afterwards, the stores places pre-orders, and combined with a forecast from the marketing department, a total estimate per SKU is send for confirmation to the suppliers. Confirmation from the suppliers are essential to ensure the high availability requirements in grocery retailing – and consequently, if the suppliers can not confirm the availability the product is either completely removed from the season or promotion, or a substituting supplier is found.

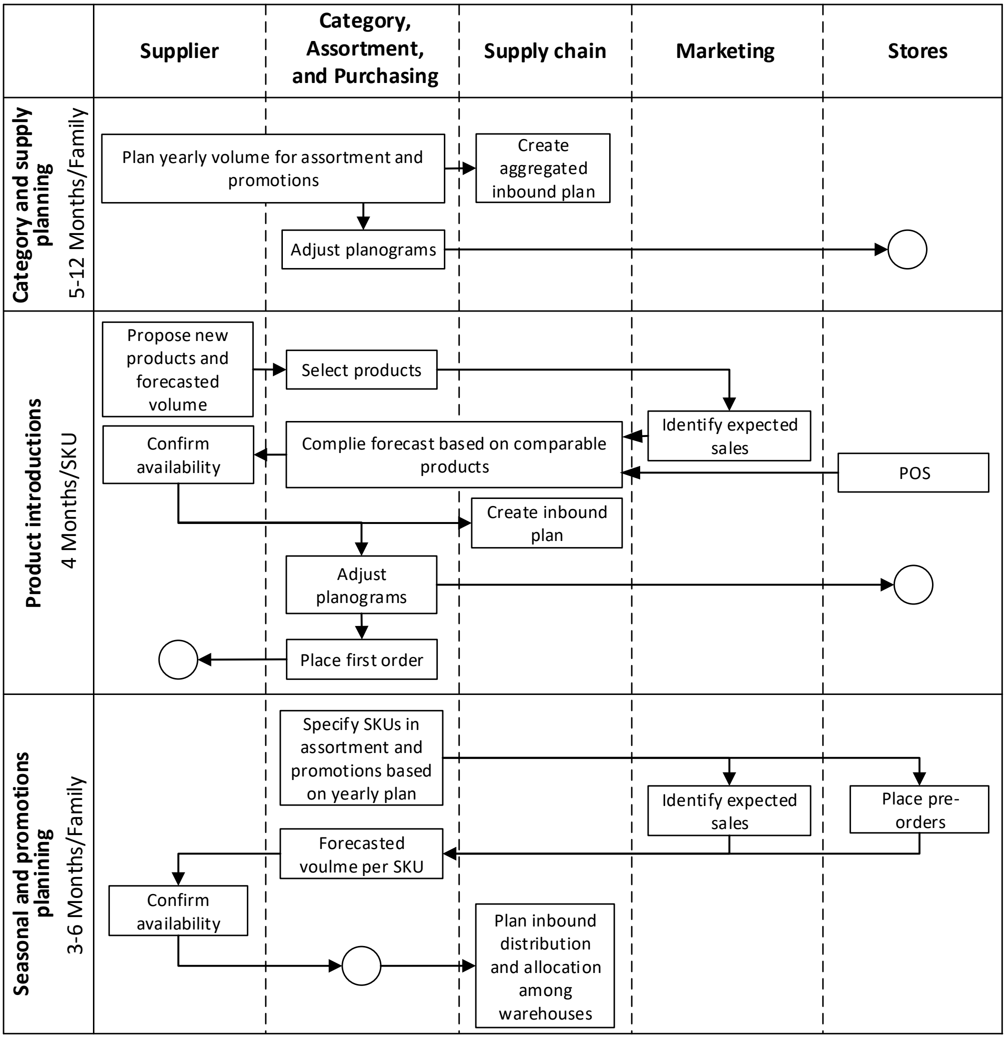

Figure 5: Tactical planning processes at Case 4

4.4.2 Mechanisms for integration

The planning aims for cross-functional coordination supported by the executive level, especially in the beginning of the process. However, the mid-term planning is driven by sales targets and market activities and is initiated by the category and assortment decisions, while the distribution aspects of the supply need to adjust to those decisions. Because new products introductions are handled as a separate process there is a risk that the inter-relationship between products may not be fully observed. Suppliers and stores are mainly involved by providing pre-orders and confirming availability (except when making yearly supplier agreements).

Data for all the planning activities are collected and processed in six different IT systems where the main planning component is made using a spreadsheet-based system. POS data is the main input for the planning and forecasting. The distributed IT platform makes the process time consuming, comprehensive and complex. Lastly, a wide set of measures are applied in the yearly planning in order to review the status, such as forecast accuracy, fill rate, inventory levels and costs. Table 8 summarizes the integration mechanisms.

Table 8: Integration mechanisms in Case 4

Mechanism	Observations
Meetings and collaboration	Cross-functional involvement. Involvement of suppliers and customers. Separation between central and decentral planning.
Organisation	Executive support in the yearly planning and a rather well defined tactical planning team.
KPIs	A wide set of functional measures applied. No cross functional measures.
IT	Data from six different IT systems are collected into one single spreadsheet.

5. Cross case analysis

Here we make observations across cases about how the planning process is designed, and how integration in tactical planning is realized in retailing context. We follow the variables of S&OP process and integration mechanisms by Grimson and Pyke (2008). The main contextual factors dealt with are demand variability, a broad product, supplier and store base, making the whole industry prone to promotions, seasonal sales activities and frequent product introductions. The analysis show that the number of SKUs increases in retailing when the customer base consists of many different retail chains with different store concepts. The cases also indicate that retailers are not planning supply on a tactical level, but they are relying on supplier capabilities to deliver agreed on in yearly contracts, supported by retailer preorder practice and supplier forecasts.

5.1 Tactical planning process

First, we address how specific context factors affect process activities and set-up. Tactical planning on two levels of aggregation is observed in all the cases. Aggregated category/assortment and promotions planning on a product family level, up to 12 months' time horizon, per retail chain (case 1) is observed in three of the cases (1, 3 and 4). In Case 2 (wholesaler) this is done by the retailer customers. Aggregation reduces complexity and uncertainty, originating from a large number of heterogeneous products, requirements from multiple retail stores and demand fluctuations, and confirms supply volumes and prices from a broad supplier base. An aggregated logistics plan is made in Case 1 and 4 to deal with the large number of stores (1,200 and 600 respectively compared to the 28 stores in Case 3), and in Case 2 to be able to respond timely on capacity variations. The frequency of aggregated planning varies remarkably across cases. It may be made annually as in Cases 1 and 4. While Case 3 interestingly conducts aggregated planning bi-weekly in the event planning meeting (EPM), which can be explained by the limited customer base, higher use of local suppliers and proactive offering of seasonal and a relatively narrow assortment compared to the other cases.

The companies are typically conducting more detailed planning for specific demand situations (SKU level with varying time horizon, depending on the type of the event). In Cases 1 and 2 there is separate planning process for product introductions, promotions and seasons respectively, while Case 4 conducts promotions and seasons planning jointly in one process, and Case 3 has integrated all events planning into one joint process. Reason for separating planning seems to be in the nature of the event and the related demand uncertainty leading to different activities and their timeline respective for each event. Case 4 is a discount retailer with only one type of store concept so the promotions might not cause so large effect on the demand. Promotions and seasonal planning follow similar processes initiated by the retailer aiming to increase sales (price, product and marketing mechanisms) in Cases 1, 3 and 4 or by customers in Case 2. The product introduction process differs from this in the initiating phase where the driver (in all cases) basically is the supplier which enables them to affect demand both on the new products and on existing products.

Demand forecasts made from POS data is the main planning input in all cases, supported by store preorders and suppliers forecast particularly for product introduction (Case 1 and 4) in order to improve the relatively low level of forecast accuracy. In case 2 the wholesaler develops the forecast jointly with the customers. Case 1 and 4 apply yearly supplier contract as input to stabilize supply (volume, price and delivery terms) since the supplier portfolio is broad and the lead time and availability requirements are essential. Input related to planning supply operations, such as capacity at the warehouse, stores, or in a distribution route, mainly act as planning constrains rather than point for optimization. Other types of downstream input, typical for Case 3, is the consumer and store feedback, and external events, which are probably easier to consider because of the small number of stores and closer relation to the community/suppliers related to the stores.

Sales plans are the main outcome in all the cases, but it differs how and if the planning of promotions, seasonality and product introduction are coupled. In Case 1 and 2, the outcome is mostly sales plans for the individual events, in Case 3 there is a joint plan, and in Case 4 seasonality and promotions are planned jointly. This might be the result of the combination of number of products and stores, where Cases 1 and 2 have the largest and Cases 3 and 4 smallest combination. In Case 1 the sales plans for product introductions lead to adjustments of store planograms, which require efficient store management because of the size of the assortment and number of stores. Case 2 does not have influence on the planograms (they are under direction of the different chains), but uses sales plans for logistics capacity planning. Case 1 and 4 also have inbound plan and allocation across warehouses as an outcome of season and promotion planning process, which might be needed because of a larger number of warehouses and a large effect of these events on the logistics part.

5.2 Planning integration

As a general observation can be stated that integration of tactical planning in retailing seems to be limited compared to how manufacturers have adopted S&OP. Functional roles seem to be strong in retailing, and this is supported by measurement system which lacks cross functional elements. The retailers also protect their position in the supply chain which has included tenses between actors, which may affect collaboration. The retailers are the important market portal and distribution channel for suppliers, which increases supplier dependency on retailers. Suppliers have traditionally served retailers by short delivery times and high delivery reliability, which reduces the retailers need and benefit from planning. Suppliers are however brand-owners in many cases, and they are actively affecting demand by offering new product, discount and delivery terms.

Meeting practices and collaborative activities across functions are used in Cases 3 and 4, not with a purpose to align sales and operations plans (as it is in manufacturing) but to align across different events and across sales and marketing (Case 3) or to improve the forecast (Case 4). Because sales and demand boosting seems to be the key profit drivers, and not as in manufacturing to affect profit by alignment across functions, it seems that cross functional information sharing is more appropriate than meetings and collaborative plan development.

Collaboration (purchasing function) with suppliers is used in Cases 1 and 4 for the aggregated sales planning, but also in the more detailed sales planning in Case 3. In Case 3, similarly to S&OP in manufacturing, there is a team of planners and a formal meeting and collaboration structure including suppliers. This creates flexibility and capability at Case 3 to adjust and respond to external events such as festivals and other market requirements.

Customer collaboration (purchasing function) is a practice in all the planning processes of Case 2 in order to jointly create, test and approve the forecast. Case 2 in comparison with the other cases does not own the retail chains and therefore needs to establish higher collaboration to be able to identify the demand more accurately. Contrary to the call for internal integration as a prerequisite for external integration (Grimson and Pyke, 2007; Alftan *et al*. 2015;), the four retail cases involve to a certain extent suppliers (forecasting, product availability, pricing agreement) and customers (pre-orders, consumer feedback) in the planning process, but they do not necessarily involve all internal functions. Purchasing function has the key coordinator role in three of the cases (1, 2 and 4).

We observe that under a higher executive support and involvement (Case 3 and partly in Case 4), the case companies tend to have more formal and integrated planning. Consequently, in case of limited executive support the cross-functional collaboration decreases and the process becomes more sequential (Case 1 and 2). Balancing between logistic plans and demand plans does not happen, and the focus seems to be on developing sales plans, while the logistics plan follows and responds accordingly.

All case companies have defined performance measures, but only Case 3 established measures (such as profit, and promotion effectiveness) which drive cross-functional balancing, horizontal collaboration and improving performance. Case companies 1, 2 and 4 measure individual functions performance. Case 2 reviewed the forecast accuracy together with the customers; Case 3 and 4 involve suppliers in forecasting and Case 1 receives forecast from suppliers, particularly valuable for product introductions, indicating external integration. Except from forecast accuracy, measures as inventory levels, service level, and picking error were also reviewed in most cases.

Sharing spreadsheets or information directly in a common IT system may provide more detailed information of particular SKUs, being an important integration mechanism compared to meetings in a context with a wide assortment, supplier and customer base. More advanced IT systems can support and enable a more mature S&OP process (Lapide, 2005) as observed in Case 3. However, it does not guarantee planning integration, as seen in Case 1. On the other hand, advanced IT systems are not necessary for an integration of tactical decisions (Case 4) – even though it would be more efficient. All case companies' emphasize the role of IT for external communication and information exchange with suppliers and stores, which can compensate for lack of collaborative planning activities, plan integration and making consensus. Cases 1 and 2 have invested in advanced planning software, and are successfully using it for replenishing the stores continuous assortment but they still have separate planning processes for product introductions, seasons and promotions. In case 4, there are attempts to integrate different plans, but the company suffers from a fragmented set of IT systems, which makes integrating the plans complex.

6. Proposals for grocery retailing

Retailers are positioned close to the market and are dealing with a heterogeneous spectrum of products, making them focus their planning on demand and market events and securing product availability from suppliers. This observation about consumer orientation in retailing is also emphasized in the literature (Agrawal and Smith, 2009; Hübner and Kuhn, 2012), but the supplier and cross-functional integration and how planning is conducted has been less evident in previous studies.

In contrast to the S&OP process in manufacturing industries (Thomé *et al*., 2012; Ivert *et al*., 2015; Oliva and Watson, 2011), where balancing demand and supply is the aim, the situation in retailing seems to be that operational supply function (logistics) is an instrument for achieving demand targets rather than optimizing demand and supply in the same planning process. In manufacturing, the main objective is to align operations and market requirements to given constraints in resources and with a satisfactory utilisation of capacity (Goh and Eldridge, 2015). Retail planning comprises a complex and abundant assortment, supplier and store base with logistics as the main resource and constraint. The planning objectives in retail are oriented towards high availability and efficient handling of a broad range of products and high volumes to reach scale benefits (Cachon and Kök, 2007; Fernie *et al.*, 2010; Hübner and Kuhn, 2012). However, when there are constrains or pressure on the logistic systems, especially when market events overlap, managing demand and supply will be challenging if decisions are not coordinated. Even if capacity is not at major constraint in retailing, challenges related to high inventory, cost of waste and transportation is evident, which can be dampened in a balanced planning approach. Consequently, for grocery retailers, the S&OP process should be understood as a balanced and coordinated decision making process to reach the unified targets of the planning (Tuomikangas and Kaipia, 2014).

Particularly important and beneficial would be to adopt the aligning of demand and supply and the formal nature of S&OP, to advance internal and external integration, and to align tactical planning to strategic and operational planning. Improved alignment of functional plans and event plans in tactical planning in grocery retailing would have a positive effect by reducing demand and supply uncertainty and hereby improve availability, reduce inventory and waste, and optimize the use of the logistics system. Hence we argue:

> *Proposition 1: Because of the nature of demand management in grocery retailing, particularly seasonality, promotions, and frequent product introductions, tactical planning would benefit from adopting a more formal planning process, integrating functions and sub plans into a single plan with shared planning objectives.*

Reaching consensus on demand and supply targets requires management involvement, strong management support and a structured S&OP process (Vieira *et al.*, 2009; Tuomikangas and Kaipia, 2014; Goh and Eldridge, 2015). By exploiting the insight from tactical planning in our grocery retailing cases analyzed by the S&OP process concepts, we propose a structure for the S&OP process in grocery retailing in Figure 6.

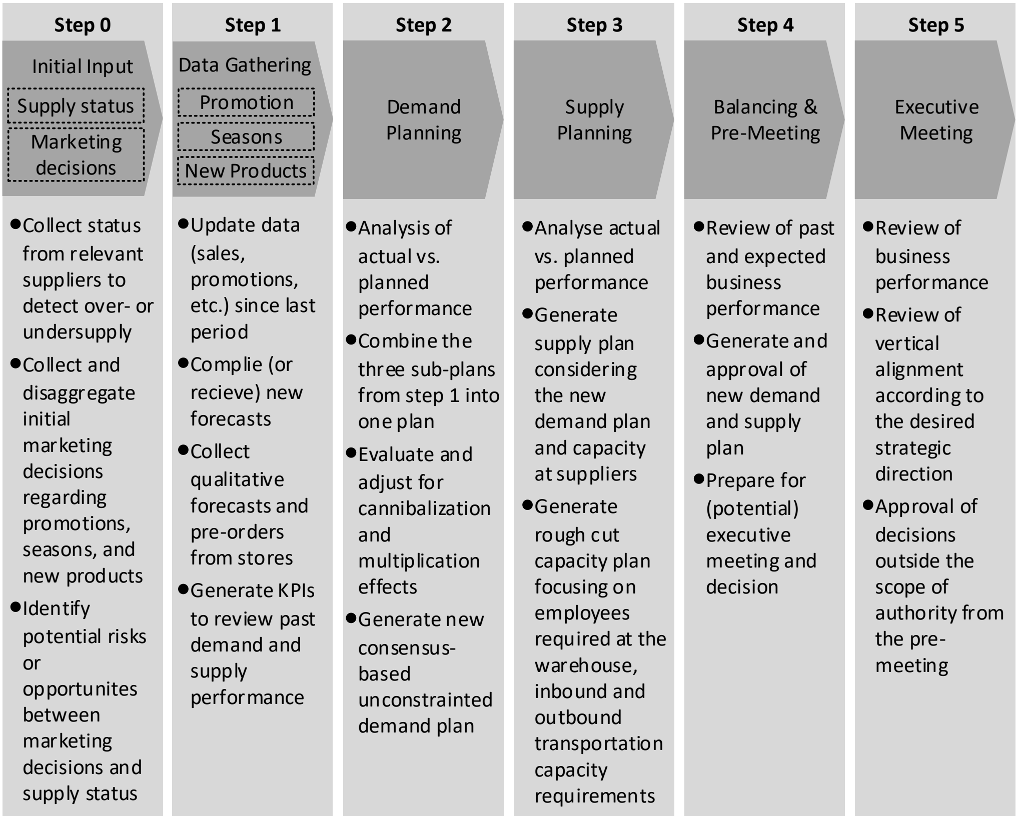

Figure 6: Proposed S&OP process for grocery retailing

Step 0 is an initial input where aggregated market decisions regarding sales, promotion and similar demand stimulated events are collected and compared to the status at the suppliers. In addition, over- and under-supply events information are gathered. Yurt *et al.*, (2010) proposed to add a similar step of initial supply planning after the data gathering. In addition, in all cases we observe that this initial input takes place at the very beginning of the process and is essential for grocery retailing. Step 1 includes three parallel processes for gathering data to establish initial unconstrained plans of three demand stimulating activities. The three plans are later combined in Step 2 where a joint unconstrained demand plan is formed. Step 3 is the generation of the supply plan, where capacity at suppliers is considered, as well as the inbound and outbound transportation capacity. At Step 4 the demand and supply plans are approved together with a review of performance. In case of disagreement or need for radical decisions, an executive meeting should take place as the last step.

We envision that the setup of S&OP process in retailing should have a horizon of approximately 6 months, or over the next sales season, as seasonal sales very much characterize grocery retailing. Some decisions, e.g. promotions, might be at a more gross level as the horizon becomes more than 3 months out. Important here is to acknowledge that planning horizon is variable, and should fit to the environment of the individual retailer – if new product introductions have a horizon of 8 months the horizon of the S&OP process should be adjusted accordingly. The planning frequency is monthly, but should be adjusted if opportunities or risks arise from the supply side (e.g. due to availability problems) or at the demand side (e.g. due to competitors actions, new stores, etc.). Since the focus on demand-stimulating activities is so strong, the S&OP process can be conducted on an SKU-level, as also reflected in all four cases and have been previously reported as norm in the food and grocery retail industry (Holmström *et al.*, 2002; Ivert *et al.*, 2015).

6.1 Increasing integration in grocery retailing through S&OP

The S&OP literature suggests that strategic alignment and top management ownership, as well as shared planning objectives (Thome *et al.*, 2012; Wang *et al.*, 2012; Tuomikangas and Kaipia, 2014) and cross-functional planning is necessary for S&OP to succeed (Grimson and Pyke, 2007; Tuomikangas and Kaipia, 2014). This may have a positive impact on performance (Thomé *et al.*, 2014; Goh and Eldridge, 2015) since it will be efficient, coordinated and not conflicting (Agrawal and Smith, 2009; Olivia and Watson, 2011; Alftan *et al.*, 2015).

In this study, the grocery retailers applied either functional and sequential planning with limited coordination, or planning in cross-functional teams of managers with the aim to coordinate across sub-plans and functions and to reach shared planning objectives. The latter is close to the essence of S&OP planning, and by using this practice flexibility and the ability to respond to varying volumes can be created. From our cases, we understand that reaching a company-wide planning process will require changes to how planning is perceived and managed. Tactical planning seems not to be given strategic importance nor supported widely by management. Executive support and participation was limited. Therefore, we find that the planning culture is functionally oriented and that planning leadership is unclear. Consequently, we propose:

> *Proposition 2: Grocery retailers's planning-related culture and leadership should facilitate and enhance formal collaborative planning and foster a supply chain perspective to the planning. This includes support and ownership from top management, shared objectives for planning, rewards and empowerment.*

This study shows that even at low level of functional integration, suppliers and stores were to some extent involved in the planning. However, this also shows that the retailers place a conscious focus on involving external parties, but a weaker awareness on internal integration. We find the internal integration equally important as the external integration in retailing and it appears that the current organizational structure does not place a responsibility nor authority to ensure cross-functional planning. Therefore, we suggest:

> *Proposition 3: Grocery retailers would benefit from an organizational structure with dedicated responsibility to integrate functional decisions from category and assortment, purchasing, and logistics to reach a single consensus-based tactical supply and demand plan.*

External and internal collaboration can intensify each other (Stank *et al*., 2001; Sadler and Hines, 2002), and supplier integration should be pursued simultaneously with deployment of internal S&OP practices (Thomé *et al*., 2014). The S&OP literature suggests that suppliers and customers should be included in the planning process (Affonso *et al.*, 2008; Wang et al., 2012). In our cases, suppliers were involved in the planning either by taking part in discussions about market targets and forecasts, or by sharing information about new product development. Involving suppliers was a mean for the retailers to stabilise supply in terms of availability and especially for new products. Stores in general seem to be less actively involved in the planning except for placing pre-orders and giving feedback on market surveys. Therefore, we propose:

> *Proposition 4: Grocery retailers would benefit from a supply-chain wide planning perspective, which actively seeks to involve suppliers and customers into their tactical planning process to adequately understand demand, create demand, and ensure availability of products.*

Information technology as an integration mechanism in manufacturing becomes more important when moving to a mature process (Ivert and Jonsson, 2010; Oliva and Watson, 2011). However, at the retailers, it seems that this mechanism is not necessarily related to the maturity of the planning process but merely to increase the speed and handle the complexity of the process. Case 4, for example, presents one of the highest levels of integration but uses fragmented IT systems and spreadsheets for planning and coordination. The reason why IT can speed up the process could be explained by the planning complexity. In grocery retailing the process may include different planning intervals and planning is handled on SKU-level per store which makes discussing all details (in physical meetings) inefficient compared to using more advanced IT solutions. Thus, we propose:

> <u>Proposition 5:</u> *A single integrated IT solution may contribute to the efficiency and communication of the tactical planning process in grocery retailing due to detailed planning on SKU-level, but does not ensure integration without changes in planning orientation.*

Integration is also expected to increase by use of relevant performance measures (Grimson and Pyke, 2007; Thomé *et al*., 2012). All cases showed a strong focus on evaluating the forecast accuracy, which indeed also can be considered as an important and relevant measure for the S&OP process (Thomé *et al*., 2012). However, it is not clear how this measure alone stimulates integration of functions and the different sub-plans in retailing. More formal evaluation of performance through cross-functional measures appears to be lacking in retailing. This should be an essential part of the data gathering and pre-meeting (Step 1 and 4 in Figure 1). Harwell (2006) proposed to evaluate performance through gross profit compared to display space in the store. Increasing performance here would require an excellent assortment and pricing decisions as well as outstanding balance of supply and demand. More generally we propose:

> <u>Proposition 6:</u> *Grocery retailers would benefit from a cross-functional and process-level planning performance evaluation which should be used as an input for the next planning round to gradually improve knowledge on demand stimulating activities.*

7. Conclusion

In this study, the S&OP process and integration elements are used to investigate how grocery retailers are conducting tactical planning. In particular, we analysed the planning process and how it integrates company functions, different sub-plans and external supply chain partners. Our empirical findings indicate that in grocery retailing, since the retailers are close to the market and are dealing with a heterogeneous assortment of products, the planning process focuses on demand-stimulating events and securing product availability from suppliers in order to reach sales targets. Less attention is directed towards aligning demand and supply, or to providing a single plan to guide company operations. For the level of process integration, planning was functionally oriented with limited coordination between functional plans, but included some level of external integration – mostly for improving forecast accuracy.

The main contribution of the study is the proposal that retailers would benefit from a formal and company-wide S&OP process. Adopting S&OP principles from manufacturing, retailers would better unify different market-oriented plans to a single set of numbers, and balance demand and supply, without sacrificing the high emphasis on demand planning and managing marketing events important in retailing business. This enhance existing retail planning literature (Olivia and Watson, 2011; Hübner *et al.,* 2013; Kuhn and Sternbeck, 2013) and enrich the S&OP literature with a retail specific study (Thomé *et al.,* 2014). Managerial-wise, the study gives a proposal for a formal S&OP process in retailing, extending the proposal from Yurt *et al.* (2010). Furthermore, the study suggests ways to increase integration by top management ownership, shared planning objectives and reward mechanisms. The organization structure should foster responsibility for integrating functional plans, and involve suppliers and customers in the planning. Integrated IT solution may increase planning efficency but does not ensure planning integration, while evaluating the performance of demand management activities would gradually improve knowledge about the impact of market events to enhance tactical planning.

Although the research benefits from rich and exploratory data from the grocery retail sector in Finland, Norway and the UK, it has limitations that require further research. First, the focus of the study was on the retailer which was the sole provider of the data, leaving out information from suppliers and customers. A deeper insight would be needed into the integration of supply chain partners in the planning, in particular in order to explore exact how suppliers and customers could enrich the planning process and integration. Second, we studied four cases from three different countries in grocery retailing. Comparisons of different retail industries with larger data sets would be valuable in helping to understand the planning environment and the contextual characteristics of retailing. Third, IT and information sharing are important in retail because of the planning complexity involved and further research should look deeper into decision complexity and the use of advanced decision support systems to improve information usage, decision making and analytics. Forth, future studies could include a verification of the process and propositions.

8. Acknowledgements

The authors gratefully acknowledge the Norwegian Research Council and the BIA programme for their financial support of the project, as well as the participating case companies, which together made it possible to carry out this study.

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ISSN (online): 2446-1636
ISBN (online): 978-87-7210-110-1

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